FACULTY OF ENGINEERING OF THE UNIVERSITY OF PORTO

"*Industry 4.0 and Transversal Skills: comparing social sciences and STEM higher education graduates"*

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June, 2019

To my parents, who taught me to be a fighter.

Acknowledgements

First and foremost, I would like to thank my two supervisors of this dissertation, Professor Maria Helena Gonçalves Martins and Diana Aguiar Vieira, for all the support, motivation, and patience during the last eight months.

Thanks to Professor Alexandra Cristina Lopes, for the help on the statistical portion of this dissertation.

To achieve this life goal of concluding successfully the studies cycle of Master Program in Innovation and Technological Entrepreneurship, I will remain extremely thankful for all the support my parents have given me.

Finally, to the rest of my family and friends a special note of gratitude for always being by my side, for the wise words during this period, for the motivation and accompaniment throughout this journey, and for the encouragement to never underestimate my ability to pursue my goals with courage.

You have my many thanks!
Ana Carolina Pereira Barros

Agradecimentos

Em primeiro lugar, gostaria de agradecer às minhas duas orientadoras, a Professora Maria Helena Gonçalves Martins e Diana Aguiar Vieira, por todo apoio, motivação e paciência durante os últimos oito meses.

Agradecimentos à professora Alexandra Cristina Lopes, pela ajuda na parte estatística desta dissertação.

Para atingir este objetivo de vida de concluir com sucesso o ciclo de estudos do Mestrado em Inovação e Empreendedorismo Tecnológico, ficarei extremamente agradecida por todo o apoio que meus pais me deram.

Finalmente, para o resto da minha família e amigos uma nota especial de gratidão por estarem sempre ao meu lado, pelas palavras sábias durante este período, pela motivação e acompanhamento ao longo desta jornada, e pelo encorajamento para nunca subestimar a minha capacidade de perseguir os meus objetivos com coragem.

Vocês têm os meus maiores agradecimentos!
Ana Carolina Pereira Barros

Abstract

The twenty-first century brought forth the phenomenon of the fourth industrial revolution which is currently taking place at a global scale. This is the result of the technological advances that are causing disruption across industry sector, representing a paradigm shift on existing business models and in the economy as a whole. Considering the social and educational transformations from the first three industrial revolutions, there is reason to believe that educational institutions will need to rethink their practices and focus on the development of skills, especially transversal ones, that enable future graduates to handle their future working roles. It is expected that the confluence between humans and machines will reduce the subject scope between humanities, social sciences together with science and technology, since many skills such as interdisciplinary work, ability to speak foreign languages, ability to think creatively and lifelong learning, will stand across different sectors and will be needed independently of the knowledge area.

This dissertation aims to analyze how Portuguese higher education institutions are responding to these transformations, and how graduates from different knowledge areas - Social Sciences and STEM (Science, Technology, Engineering, and Mathematics) - are developing the transversal skills needed for the Industry 4.0 framework. To this end, a questionnaire that evaluates a set of 21 transversal skills was used in order to understand the degree of preparation given by higher education institutions, level of confidence and usage among 768 graduates from three different knowledge areas (1) Social Sciences, Commerce and Law; (2) Sciences, Mathematics and Informatics and (3) Engineering, Manufacturing and Construction. This work used an existing database from the work elaborated by Vieira and Marques (2014), adding new insights by using variables that were not previously analyzed in depth in the previous study. Focusing on these three main knowledge areas, this dissertation intends to inform different stakeholders, such as policymakers and higher education [HE] systems, about which transversal skills most need to be promoted. Consequently, this knowledge may elucidate the stakeholders in order to provide and facilitate a better assessment, monitorization, and evaluation of their educational policies.

Keywords: Portuguese Higher Education; Industry 4.0; Transversal skills; Social Sciences; STEM; Graduates.

Resumo

O século vinte e um trouxe o fenómeno da quarta revolução industrial que está a ocorrer atualmente em escala global. Este é o resultado dos avanços tecnológicos causadores da rutura em todo o setor industrial, representando uma mudança de paradigma nos modelos de negócios existentes e no conjunto de toda a economia. Considerando as transformações sociais e educacionais das primeiras três revoluções industriais, há razões para acreditar que as instituições educacionais precisam de repensar as suas práticas e focar no desenvolvimento de competências, especialmente transversais, que possibilitem aos futuros graduados lidar com os seus futuros trabalhos. Espera-se que a confluência entre humanos e máquinas reduza o escopo entre humanidades, ciências sociais e ciências e tecnologia, já que muitas competências, como o trabalho interdisciplinar, a capacidade de falar línguas estrangeiras, de pensar criativamente e aprendizagem ao longo da vida, serão necessárias em diferentes setores e independentemente da área de conhecimento científica.

Esta dissertação tem como objetivo analisar de que forma as Instituições de Ensino Superior Portuguesas estão a responder a estas transformações, e como os graduados de diferentes áreas de conhecimento - Ciências Sociais e *STEM* (Ciência, Tecnologia, Engenharia e Matemática) - estão a desenvolver as competências transversais necessárias ao enquadramento da Indústria 4.0. Para esse efeito, foi utilizado um questionário que avalia um conjunto de 21 competências transversais para compreender o grau de preparação das Instituições de Ensino Superior, nível de confiança e uso entre 768 graduados de três diferentes áreas de conhecimento (1) Ciências Sociais, Comércio e Direito; (2) Ciências, Matemática e Informática e (3) Engenharia, Indústrias transformadoras e Construção. Este trabalho utilizou uma base de dados existente a partir do trabalho elaborado por Vieira e Marques (2014), adicionando novas análises, e também utilizando variáveis que não foram previamente analisadas em profundidade nesse estudo. Tendo em foco estas três principais áreas do conhecimento, esta dissertação informará aos diferentes *stakeholders*, como as entidades políticas e os sistemas de ensino superior, quais as competências transversais que precisam de ser mais promovidas. Consequentemente, este conhecimento pode elucidar as partes interessadas a fim de fornecer e facilitar uma melhor avaliação, monitoramento e avaliação das suas políticas educacionais.

Palavras-chave: Ensino Superior Português; Indústria 4.0; Competências transversais; Ciências Sociais; STEM; Graduados.

List of Abbreviations

ANOVA	Analysis of variance
CNAEF	Classificação Nacional de Áreas de Educação e Formação
CPS	Cyber-physical systems
HEI	Higher Education Institution
ICT	Information and Communication Technology
IoT	Internet of Things
IT	Information and Technology
MANOVA	Multivariate Analysis of Variance
RFID	Radio Frequency Identification
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering and Mathematics

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"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn"

Alvin Toffler

1. Introduction

Recent technological advances in all fields of human life reflect some of the developments that propelled what is called the fourth industrial revolution that is currently taking place (Caruso, 2017; Ghislieri, Molino, & Cortese, 2018).

The concept of "industrial revolution" appeared in the eighteen century when the steam machine allowed the expansion of the manufacturing development, and agrarian and handicraft economies in Europe and America were transformed into industrial urbanized zones (Stearns, 2018). The second industrial revolution happened in the nineteenth century when innovations and progressions in manufacturing related to the utilisation of electricity allowed the increase of productivity, improvements in product quality, changes in the organisation of production, economy of scales while decreasing the amount of human labour needed (Mokyr, 1998). The use of Information and Communication Technology (ICT) and the use of electronics to automate production characterized the third industrial revolution in the sixties of the twenty century (Dalenogare, Benitez, Ayala, & Frank, 2018).

The twenty-first century brought about the phenomenon of the fourth industrial revolution which is characterised by intelligent networking between humans, machines, and products (World Economic Forum, 2018). The fourth industrial revolution is a worldwide phenomenon where the landscape of jobs is predictably going to be impacted by robots and automation (Frey & Osborne, 2017; World Economic Forum, 2018) due to "lower costs, higher quality, improved safety, and environmental protection" (Ghislieri et al., 2018, p. 2). In spite of this situation which may trigger fear for workers in terms of future job losses (Ghislieri et al., 2018), it is important to mention that a job having a high risk of being automated is not necessarily significant with total job loss. In fact, other types of jobs can be created, and others that will be lost can be relocated to other regions (Rajnai & Kocsis, 2017, September). The term of the fourth industrial revolution was introduced during the Hannover Fair in 2011 in Germany, as "Industrie 4.0", to take a pioneering role in how companies can revolutionize the sectors that operate worldwide, in a region with high wages (Xu, Xu, & Li, 2018). In this fair, information technology (IT) companies and robotic equipment producers painted a picture of future factories where artificial intelligence plays a vital role[1].

[1] http://www.chinadaily.com.cn/a/201804/27/WS5ae29547a3105cdcf651ae80.htmlZ

The digital transformation of Industry 4.0 covers 3 main aspects: 1) digitization and increased integration of vertical and horizontal value chains, 2) digitization of product and, 3) service offering and the introduction of innovative digital business models (Geissbauer, Vedso, & Schrauf, 2016) "that are highly driven by the use of smart data for offering new services" (Stock & Seliger, 2016, p. 540).

Cyber-physical systems (CPS), IoT (Internet of Things) and Smart Factories are the most common terms when the discussion about the Fourth Industrial Revolution arises (Hermann, Pentek, & Otto, 2016, January). Cyber-physical systems (CPS) are networked computers that integrate the virtual space with the physical world by integrating computing, communication, and storage capabilities and "represents a paradigm shift from existing business and market models, as revolutionary new applications, services, and value chains will become available" (Xu et al., 2018, p. 2950). IoT is a system of interrelated computing devices that allows "things" and "objects", such as Radio Frequency Identification (RFID), sensors, actuators, and mobile phones, to be connected and interact and cooperate with each other over a network without requiring human-to-human or human-to-computer interaction (Motyl, Baronio, Uberti, Speranza, & Filippi, 2017).

The use of CPSs linked to IoT allows the intelligent production processes and smart factories through this connection between machines, interfaces, components and humans (Hermann et al., 2016, January). Furthermore, these processes aim at increasing productivity and efficiency, allowing more flexible models of work in the organization, mass customization and the integration of value chains.

Considering the social and educational transformations from the first three industrial revolutions, considerations about the potential changes on higher education systems arising from Industry 4.0 can be made. In fact, Valerie Hannon (2016), an Education Innovation Specialist, points out that education systems should be able to adapt in order to thrive in a transforming world (Hannon, 2016) where students will need to apply their knowledge to unknown situations and also be "able to think creatively, develop new products and services, new jobs, new processes and methods, new ways of thinking and living, new enterprises, new sectors, new business models and new social models" (Howells, 2018, p. 5). Nowadays, "one of the most important tasks of education is to form and develop competencies, especially transversal ones, which are basic and guarantee that individuals can handle their future roles"(Nikolay, 2017, p. 129). The role played by higher education systems especially on "continuous learning, flexibility, the ability to work in multi-functional teams and to deal with complex situations"(Ghislieri et al., 2018, p. 4) is not without controversy since "educational systems have not kept

pace with the changing nature of work, resulting in many employers saying that they cannot find enough workers with the skills they need" (Manyika, 2017, p. 2).

In terms of the future job market environment where one of the buzzwords seems to be "automation", Frey and Osborne (2017) state that there are variables that have a relatively low risk of being automatized, namely "fine arts", "originality", "negotiation", "persuasion", "social perceptiveness", and "assisting and caring for others". Furthermore, some attitudes and attributes such as resilience, creativity, and enthusiasm seem to be of crucial importance when it comes to recruiting young talent (Confederation of British Industry, 2016).

However, there seems to be a mismatch of what young people can offer after leaving university and what employers are looking for, related to the fact that new graduates do not seem to be adequately prepared for the world of work due to the lack of technical skills in STEM (Science, Technology, Engineering and Mathematics) subject degrees (Manyika, 2017) but also, lack of experience in real-world learning and the lack of essential skills such as problem-solving skills, creative thinking, oral communication and teamwork (CareerBuilder, 2015). Thus, continuous training and professional development represent a critical factor for achieving the Industry 4.0 objectives as jobs and skills profiles are transformed (Motyl et al., 2017).

In light of these reflections, considering that the fourth industrial revolution is occurring, as well as the current environment of seemingly ever-increasing automation and the subsequent changes in the job market, this dissertation aims at looking forward in a proactive attitude, comparing Social Sciences and STEM Portuguese higher education graduates in terms of their perceptions about the contribution of higher education in terms of transversal skills preparation for daily work life, analyzing their confidence and the usage of transversal skills that are important to the challenges of Industry 4.0 framework. Also, this work aims to provide some practical recommendations that may be used by different stakeholders in this area (policymakers and higher education [HE] systems) in order to facilitate a better assessment, monitorization and evaluation of educational policies. Those stakeholders "play an essential role in preventing competence obsolescence and fostering the continuous updating and development of those skills required by the current and future labor market"(Ghislieri et al., 2018, p. 4).

The importance of training and development of human skills by higher education systems has been reinforced by several authors, but recently, Traça (2018), director of the Nova School of Business and Economics stated that:

> In addition to teaching students how to handle machines, we will have to give them the skills to be able to adjust to this

change. We will have to teach them to unlearn, which means, to teach students to forget a little what they have been taught so they can learn something new. (...) It is necessary to teach how to deal with technology, to teach to learn and to unlearn, to deal with change and to teach how to be more humans because, at the bottom, everything that is not specifically human will be done by machines. (...) The future is of those who exploit. The most exceptional human skill - which no machine will ever be able to replace - is the ability to create problems, to exploit.

2. Literature Review

2.1 Structure and Methodology of the Literature Review

In this section, the concepts of soft, hard and transversal skills were analyzed in the context of an Industry 4.0, with a focus on the development of the transversal skills in the Portuguese higher education system.

Keeping in mind that the crucial point of our Literature Review is to get a vast knowledge of the actual state of the art of the points mentioned on the previous paragraph, potential articles were researched in the SCOPUS database. Table 1 describes the search stages, starting from the 10 different types of keywords and retrieving a total of 675 articles. The filtering to arrive at the 22 articles selected was made by reading and summarizing the respective abstracts. Other references that were used in the literature review were found through the consultation of the "References" section in the selected articles.

Table 1: Literature Search Procedures

Keywords	Retrieved publications (n)	Selected publications (n)
("soft skill" AND ("Portuguese" OR "Portugal") AND "education")	16	2
("soft skills" AND ("Europe" OR "European") AND "Education" AND "Higher")	38	3
(("Portuguese" OR "Portugal") AND "skills" AND "soft" AND "higher")	12	1
(("fourth industrial revolution" OR "industry 4.0") AND "skills" AND "students")	48	2
(("fourth industrial revolution" OR "industry 4.0") AND "skills" AND "future" AND "work")	26	2
("preparation" AND "soft skills" AND "higher" AND "education")	15	2
("future" AND "jobs" AND "education" AND (" industry 4.0" OR "fourth industrial revolution"))	14	1
("soft skills" AND "definition")	45	2
(("soft skill" OR "transversal competencies") AND "work" and "study")	37	5
("degree" AND "soft skills" AND "university")	86	2

2.2 Understanding the meaning of skills and the differences between Hard and Soft Skills

Before discussing the literature in detail, it is useful to explain that, throughout this work, it will be used the Vieira and Marques (2014) definition of transversal skills as the set of soft skills (personal and interpersonal skills) but also the technical skills that are also transversal to different areas of work, such as the mastery of foreign languages, as opposed to the called "hard skills" which are domain specific.

Matteson, Anderson, and Boyden (2016, p. 74) define a skill as "the ability to access knowledge from a domain-specific knowledge base and use that knowledge to perform an action or carry out a task" that can be learned and trained (Azmi, Kamin, Noordin, & Md. Nasir, 2018) and must contain some elements of action and "takes into account the interdependent concepts of attitude, belief, and value" (Matteson et al., 2016, p. 74).

There seems to be no formal agreement for a universal concept of "soft skill", thus different soft skills meanings are possible to find in the literature (Matteson et al., 2016). They can also be called as people skills, intangible skills and non-technical skills (Matteson et al., 2016). Cimatti (2016), differently from what we assume in this work, considers transversal skills as the same as soft skills.

Gruzdev, Kuznetsova, Tarkhanova, and Kazakova (2018) define soft skills as the set of personal skills that facilitate human interactions between people within an organization and "they usually include social competences, intellectual competences, competences determining the organization and self-organization of activities" (p. 696). This kind of skills can be dependent on which position a worker occupies on an organization in terms of hierarchical structure (Nilsson, 2010).

Hard skills are directly related to a specific job or task, and can be for example, the ability to work with a specific machine or know how to work with an Enterprise Resource Planning System (ERPS), "while a Soft Skill is his capability of collaborating with the colleagues working at the same factory department" (Cimatti, 2016, p. 98). Also, "Hard Skills allow Man to be what he is: an engineer, a physicist, a philosopher"(Cimatti, 2016, p. 99). Hard skills are part of university curricula and are what usually constitutes the curriculum vitae in terms of education, work experience, level of expertise, and it has to do about what we know, more than what we are (Robles, 2012).

In the past, manufacturing companies were focused on hiring workers based on their technical skills (Cimatti, 2016); nowadays, the quality of human capital is regarded

as a central element to achieving performance, not only because of technical skills but also for transversal skills that deserve special attention by companies human resources (Cimatti, 2016). It is worth noting that "American scientists proved that 75-85 % of professional success depends on soft skills and only 25-15 % on hard skills"(Gruzdev et al., 2018, p. 696), which can be an explanation of why "current and future business leaders are emphasizing the development of soft skills" (Robles, 2012, p. 453). Also, it is shown by Carvalho and Rabechini Junior (2015) that when considering the influence of the hard and soft skills sides of risk management on project success, soft skills have a significant positive impact not only on the hard side of risk management but also on project success.

According to employers, soft skills show predominant importance for the general success of higher education graduates in organizational activities (Gruzdev et al., 2018). These non-technical skills are not easy to measure (Matteson et al., 2016), but they can be taught in class, especially on work groups, practical essays, and the respective presentation and discussions. Soft skills include qualities that are related to the ability to deal with challenges, positive attitude, ideas communication and interpersonal relationships (Metrolho, Ribeiro, Silva, Silva, & Barbosa, 2017). Also, Boyce, Williams, Kelly, and Yee (2001, p. 46) state that "case studies provide the opportunity to incorporate a range of teaching and assessment strategies that encourage students to develop a deeper understanding of the subject matter and require the application of generic skills".

Both, hard and soft skills coupled can impact positively on productivity (Grugulis & Vincent, 2009) and must to complement each other (Robles, 2012), especially when they have been developed in an educational context. They can be integrated within each discipline in the form of a work project, case studies, learning games, for example, or specific initiative as workshops or coaching (Cimatti, 2016).

"Soft Skills give Hard Skills the required plasticity to develop and keep up-to-date in changing circumstances" (Cimatti, 2016, p. 99), so, it is common to say that hard skills help people get a job while soft skills help to keep it (Robles, 2012).

2.3 Analysis of the importance of soft skills to drive Industry 4.0

The rapid pace of recent technological and environmental changes will have an impact on millions of jobs around the world and facilitate the emergence of new industries, and business organizations, competing in a globalized market, reaching high levels of efficiency of production and consumption, expanding existing or new products into new markets (Shamim, Cang, Yu, & Li, 2016, July; World Economic Forum, 2018). Process and customer-orientation are predicted to increase as well as innovation, and impulsion the intrapreneurship and employee development (Yasin, Gomes, & Almeida, 2009). Creativity will be increasingly needed from employees to benefit from the

avalanche of new products, new ways of working and doing things in this technological environment (Cotet, Balgiu, & Zaleschi, 2017; Shamim et al., 2016, July). This vision will bring customers to the epicenter of the economy, requiring a "growth in roles that leverage distinctively 'human' skills such as Customer Service Workers, Sales and Marketing Professionals, Training and Development, People and Culture, and Organizational Development Specialists as well as Innovation Managers" (World Economic Forum, 2018, p. 8). The future employees and graduates are seen in an organization as problem solvers and opportunity seekers in a more globalized and networked world (Yasin, Gomes, & Almeida, 2009). Additionally, they must adapt to new requirements and challenges of the more automatized workplace (Ras, Wild, Stahl, & Baudet, 2017, June). Azmi et al. (2018) state that that creativity and innovation are two primary skills demanded by Industry 4.0, together with, entrepreneurial skills which will be in high demand by employers in this era. For that reason, the spirit of creating and trying new things should be encouraged by every knowledge area, from STEM to Social Sciences. Also, one of the challenges for future organizations design is to guarantee the space for creativity, transparency and quick decision making (Bauer & Vocke, 2018, July) under a high level of uncertainty (Ras et al., 2017, June).

Industry 4.0 and the underlying technological innovations can influence the relative importance of future skills (Gábor, Szabó, & Ahmed, 2017, October). Lifelong learning, the skillset to self-educate (de Andrade Régio, Gaspar, do Carmo Farinha, & de Passos Morgado, 2016) and social skills will have great importance in the future of work, whereas efficiency, productivity and routine tasks (Caruso, 2017) will be mostly carried out by intelligent assistance systems. In this context, creativity (Ras et al., 2017, June), innovative thinking (Cotet et al., 2017), originality and initiative, persuasion, negotiation, ability to translate consumer values and needs into new products offerings (World Economic Forum, 2018), loss of fear of risk and failure, flexibility and adaptability, collaboration and collective learning will be crucial to any organization success (Arranz, Blanco, & Miguel, 2017).

Also, in this globalized era and considering the future working scenario, companies are most likely to prefer contracting employees that have strong English and intercultural skills, thus enabling efficient global communication networks among their workers, suppliers, and clients (de Andrade Régio et al., 2016). The Portuguese context reflects this trend and, it is possible to observe increasing concern in hiring candidates that are fluent in foreign languages. Although the proficiency in foreign languages is a transversal skill, that is possible to apply in any work context, Portuguese graduates still demonstrate a medium level of confidence of its use in their daily work life present which may be partly explained by their perception that the preparation provided by higher education institutions (HEI) on this skill is not so strong (Vieira & Marques, 2014). On

Portuguese context, it is common this skill to be learned in an extracurricular context and rarely within the classroom (op. cit.).

As suggested by Caruso (2017, p. 384), "Most new jobs will be in more specialized areas such as computing, mathematics, architecture and engineering. Soft skills such as sharing and negotiating will be crucial". In this context, there are some sectors that are expected to grow and that require high skilled employees, such as, chemical industry, motor vehicles and automotive parts, machinery and facility engineering, electrical equipment agriculture and forestry, information and communication technology, logistics and transport and energy (Arnold, Kiel, & Voigt, 2016; Buhr, 2015; Caruso, 2017; Eberhard et al., 2017; Witkowski, 2017; Xu et al., 2018).

The future workforce is moving from operators to problem solvers where it will be required new and specific fields skills but also social skills such as interdisciplinary thinking, empathy, cooperation, negotiation or emotional intelligence. These skills need to be encouraged by educational systems to follow the change to new roles such as Innovation Specialist, "AI and Machine Learning Specialists, Big Data Specialists, Process Automation Experts, Information Security Analysts, User Experience and Human-Machine Interaction, Designers, Robotics Engineers and Blockchain Specialists" (World Economic Forum, 2018, pp. 8,9) that will take place.

2.4 The development of graduates' soft skills by Higher Education Institutions

The confluence between humans and machines will reduce the subject scope between humanities, social science together with science and technology, which will stand for a need of much more interdisciplinary teaching, research and innovation. Nowadays, graduates face an era full of transformations driven by technology, in which higher education systems are facing questions about their own future (Xing & Marwala, 2017). This period of transformation requires certain skills that were not exactly the same as the ones required by the third industrial revolution. Transversal skills such as analysis and problem solving, people management, creativity, plan and organization need to be taught across all knowledge areas since STEM to Social Sciences (op. cit.).

The main differences between STEM education and Socials Sciences and Humanities is that STEM fields are linked "scientific inquiry, by formulating questions answered through investigation to inform the student before they engage in the engineering design process to solve problems" (Kelley & Knowles, 2016, p. 2) and the methodology above "Humanities is more holistic and repetitive, where the aim is understanding and interpreting a phenomenon comprehensively" (Morshidi & Wan, 2018, p. 197). All those "disruptive" technologies that are emerging, require huge

developments in humanities education since the focus of Industry 4.0 is especially technology, and based on this view, technology is expected to "dehumanize" education. Alternatively, however, if we are to accept that in the Industry 4.0 framework is a convergence between human and machine relationship, then it may also be expected that the distance between the humanities and social sciences and science and technology will be fundamentally reduced (Morshidi & Wan, 2018).

Despite this approximation between Social Sciences and STEM areas, what companies, nowadays, seem to look for in terms of soft and hard skills depends on several factors such as the professional role (Nilsson, 2010), job position, and company sector. The teaching of different knowledge areas differs across universities programs. Usually, " 'harder subjects' (sciences) were consistently linked to lower importance and improving skills ratings, whilst the opposite pattern was observed for 'softer subjects' (humanities)" (Chamorro-Premuzic, Arteche, Bremner, Greven, & Furnham, 2010, p. 236).

There are some sectors where hard skills are crucial such as the banking sector, financial, mathematics, accounting, auditing, and computing. Soft skills compared to cashiers/bank tellers (reference group) are extremely important to supervisors and managers, technicians, and instructors, and to a lesser extent to sales agents, and secretaries (Velasco, 2012). For roles such as an entry-level manager, organizations are looking for emotional resiliency and control, balanced entrepreneurs, with a base of people related skills. For these roles, there is still a lack of presence of personal motivation, focus, innovation, and entrepreneurship. Also, characteristics such as "creative problem solver" and "entrepreneurship" that appears with great importance in organizational context show a lack of educational protagonism (Yasin et al., 2009). For managerial positions, specific soft skills such as leadership abilities and interpersonal skills seem to be directly necessary for work performance (Nilsson, 2010). Leadership is a skill required by many sectors, although it is not excepted that recent graduates begin their careers immersed in positions with high responsibilities when they enter in a company (Pang, Wong, Leung, & Coombes, 2019). The need of information and technology skills in an Industry 4.0 context seems to be on the rise (Succi & Canovi, 2019), however, working in team is a part of the daily work of these professionals, that's why soft skills such as communication, ability to solve conflicts and to work in peers to arrive at a common goal are needed (Zhang, 2012). For engineering students, hard skills, such as computer-programing skills, are more relevant (Nilsson, 2010) due to the fact that for information systems hiring, candidates that meet an acceptable level of match with the specified technical skills are then allowed to proceed to the choice stage after the interviews (Litecky, Arnett, & Prabhakar, 2004). However, engineers consider the higher education programs are too focused on discipline and specific substantive content, including knowledge in information technology and computer programing, and not focused enough on the development of soft employability skills (Nilsson, 2010). For other

roles such as librarians Matteson et al. (2016) suggest that communication and interpersonal skills are essential. Also, Zhang (2012) elucidates the importance of communication for doctors.

Considering the Portuguese context, the plan seems to be to address educational challenges as part of its *Indústria 4.0* plan[2]. This plan has sought to advance towards Industry 4.0, through actions leading not only to large business organizations (COTEC, 2017), but also to the support of SMEs (Small and Medium Enterprises) through incentives such as *Vale Indústria 4.0*, whose purpose is " to promote the digital transformation of SMEs through the adoption of technologies that allow disruptive changes in their business models" (Compete2020, 2017).

In a country where there is a high number of STEM graduates and most companies can be categorized as small and medium-sized enterprises[3] (European Commission, 2018), Portuguese companies may struggle to find people with the right skills and practical knowledge for working in the industry (Universities of the Future, 2017). Beyond the more technical skills, basic knowledge on new technologies is required concerning their functions and potential, as well as implications for community and business. In every professional field, besides the good understanding of field-specific skills to the basis for job performance, curiosity, asking questions, motivation for lifelong learning, being flexible and open to change and having the ability “to think out of the box” to solve complex problems in various settings are important skills (Universities of the Future, 2017). Actually, Vieira and Marques (2014) and Succi and Canovi (2019) show that employers increasingly value non-technical skills, as compared to hard skills. Succi and Canovi (2019) showed that graduates rated soft skills less critical than employers when compared to technical skills. For the other hand, Vieira and Marques (2014) showed a convergence and a coincidence on both Portuguese employers and graduates relative to the group of skills elected as most important such as analysis and problem-solving, creativity and innovation, flexibility and adaptation and planning and organization.

Furthermore, when a company is developing technology for human use, the synergy and flexibility to work with people from different educational backgrounds is the key for better collaboration and the creation of new solutions. Likewise understanding

[2] https://www.industria4-0.cotec.pt/programa/medidas/ (content in Portuguese)

[3] https://www.iapmei.pt/PRODUTOS-E-SERVICOS/Qualificacao-Certificacao/Certificacao-PME/Documentos-CPME/Definicao-PME.aspx (content in Portuguese)

the interactions and possibilities of different technologies is required for working in multidisciplinary teams. It is important, according to the different knowledge areas, to have broad perspectives and interpersonal skills that complement well-developed specific knowledge skills of one's own field. Higher education institutions have an indispensable role in empowering future graduates to shape their own future by helping them develop the key transversal skills required by Industry 4.0. These skills and attitudes are needed and valorized by graduates - a study made by Pereira and Costa (2017) shows that "instill the necessity of seeking after alternative solutions to problems" and "develop my versatility to face different and adverse situations" were important variables considered by graduates in their higher education training.

In the current dynamic job market, where universities are seen as soft skills suppliers, it is surprising that almost all the employers sampled by Suleman and Laranjeiro (2018) are unsatisfied with graduates' preparation in soft skills and other personal traits, such as work attitude and maturity. Of course, some soft skills need a specific work context in order to be developed (Cimatti, 2016) but Pereira (2013, p. 116) shows that "the amount of dedication paid by the university to soft variables such as initiative to solve problems, decision making and self-trust abilities, interpersonal skills and the ability to react to and act in a stressful environment, do not match corporate demands". In order to narrow this gap, it is suggested that HEIs provide a more flexible education focused on the development and promotion of soft skills such as problem-solving, innovation and the advancement of leadership (Yasin et al., 2009).

It is shown by Pereira (2013) that if the university does not foster students with the right skills, such as "trust asset", associated with competitive advantages and work with peers - "skills such as entrepreneurship, decision making, persuasion and charisma in handling people and the importance of working autonomously yet interacting with peers and group will weaken and fade personal performance" (p.117). Universities need to rethink their alignment with corporate needs and bring transversal skills development across all courses and degrees. This is urgent because the labor market does not only depend on specific abilities and technical knowledge, but also on soft variables such as decision making, ability to deal with the stressful environment and with changes that companies might face nowadays. Also, the group of variables such as teamwork, critical and cooperative spirit, initiative and creativity are incredibly relevant at the level of fostering innovation process inside a company (Pereira, 2013).

As Vieira and Marques (2014) and Freire-Seoane, Pais-Montes, and Lopez-Bermúdez (2019) concluded, companies have become more interested in hiring people with social skills, that is "recognised as being vital for graduate success" (Andrews & Higson, 2008, p. 415). With the number of graduates increasing on a global scale (Rajnai & Kocsis, 2017, September), graduates perceive that HEIs do not provide the necessary

level of transversal skills, such as oral communication and the ability to make verbal presentations (Andrews & Higson, 2008), that are extremely required in the work environment. On the point of view of Portuguese employers, the soft skills with a low level of preparation were precisely soft skills such as leadership, risk-taking, and decision-making (Vieira & Marques, 2014).

2.5 Summary of Literature Review

The current university curriculum does not seem to reflect the future skills needs identified in the literature. The future of jobs landscape can represent a valid opportunity for the HEIs to make changes (Teng, Ma, Pahlevansharif, & Turner, 2019) starting by understanding the typical quizzes and traditional exams do not take in consideration and measure interpersonal skills (Zhang, 2012).

One of the most current debates is if the current education system is the most appropriate path to the future and innovative ecosystem and if higher education is bringing quality in terms of soft skills to their students (Succi & Canovi, 2019), independently of the different knowledge areas. Employers blame higher education institutions for the lack of those skills and continuously show their discontentment for the non-preparation for the "real work", and although "HEIs seem to have responded to this criticism and progressively addressed this issue, improvements in students' acquisition of transferable competencies still seem to be missing" (Succi & Canovi, 2019, p. 1).

It is expected that the graduates find themselves in the middle of a revolutionary technological transformation where software can perform sophisticated decision-making processes, and technology itself creates jobs characterized by their intellectual knowledge, more than hard and repetitive tasks. In an environment of robots and automation, more workers with IT skills and technical expertise will be needed. However, continuous learning, the mastery of foreign languages, interdisciplinary cooperation, teamwork, work-life flexibility, management, collaboration, flexibility and the ability to work with multi-functional teams are assuming growing importance across different sectors (Universities of the Future, 2017). Digital skills have also been increasingly earning more importance even though Arranz et al. (2017) identified that the so-called digital natives do not seem to be ready to emerge in the digital world. Although their consumption of digital tool focuses on primary means, most of them are not very specialized and are very focused on leisure.

It seems that universities lack awareness of the growing importance of the influence of soft skills for the future of the world of the work environment (Ghislieri et al., 2018). This scenario seems to be worldwide, even in countries like China, that despite

having several initiatives to promote innovation and creative thinking it appears that the traditional surface approach is still in somewhat root causing a gap on employability skills (Teng et al., 2019). For that reason, there is an urgent need to upgrade the current education policies to lead and prepare for the impact of new technologies on labor markets, not only on technical skills but also on non-cognitive soft skills to enable people to develop their uniquely human capabilities (World Economic Forum, 2018), independently if the knowledge area is related to engineer or social sciences. Authors such as Carnevale, Smith, and Melton (2011) encourage the development of hybrid programs that can take many forms but combine essentially, solid technical knowledge with a set of transversal skills. For the last, Yasin et al. (2009, p. 72) suggested that "higher institutions to re-orient the educational processes, delivery methods and performance assessment in order to equip the future workforce with the know-how required in a technologically-based, yet people-driven operational environment".

Thus, and taking in consideration that there seems to be a growing need for transversal skills across all knowledge areas from STEM to Social Sciences, this work aims at understanding how graduates from different knowledge areas in the Portuguese context report HEIs are developing the transversal skills needed for Industry 4.0 context.

3. Methodology

3.1 Research question

A few questions were addressed after analyzing the existent literature review and the expected growing sectors by Industry 4.0, relatively to the importance of future transversal skills across the different knowledge areas and pointing the situation about how higher education institutions are responding to it. Although in the literature the different knowledge areas are usually divided into two main groups: "social sciences"/ "humanities"/ "soft subjects" vs "STEM"/ "hard subjects", considering the National Classification of Education and Training Areas[4] approved by the Portuguese government, it is possible to find three main knowledge areas that are offered by higher education establishments: "Social Sciences, Commerce and Law", "Sciences, Mathematics and Informatics" and "Engineering, Manufacturing and Construction". The first one is related to "softer subjects" / "social sciences"/ "humanities" and the last two to "harder subjects"/ "STEM".

Generally speaking, there seems to be a gap in the literature concerning how different knowledge areas are promoting a portfolio of transversal skills needed for Industry 4.0 framework among their graduates. So, it is important to compare the three knowledge areas and understand: 1) according to them, which skills graduates are using nowadays on their work daily life, 2) understand the level of confidence in its use and, 3) their perceptions about the contribution of higher education in terms of those transversal skills preparation, for at the end to understand which skills need to be given more emphasis on the level of HEI preparation.

Considering the three knowledge areas of "Social Sciences, Commerce and Law", "Sciences, Mathematics and Informatics" and "Engineering, Manufacturing and Construction", and taking into consideration that no similar studies were undertaken in the Portuguese context, the main research question that will guide this dissertation will be: "How, the different knowledge areas of Portuguese higher institutions, are influencing graduates on transversal skills in terms of preparation, confidence and workplace use, for the next industrial revolution?"

[4] National Classification of Education and Training Areas or CNAEF (Classificação Nacional de Áreas de Educação e Formação), in Portuguese, is the name given for the courses offered by higher education establishments, approved by the Portuguese government through Portaria n. º 256/2005, de 16 de Março

3.2 Research Approach

This dissertation research will use an existing dataset from the "Prepared to work?" project (Vieira & Marques, 2014). The present work will analyze the data obtained from an original questionnaire developed for that project. The questionnaire consists of two parts. The first part includes questions about sociodemographic variables while the second part addresses a set of 21 skills: twenty transversal skills (both soft skills and technical skills) and field-specific skills. Graduates evaluated the twenty-one skills using a Likert response scale with five points (1= very low, 2 =low, 3= average, 4= high and 5= very high), in three different dimensions: i) the degree of skills usage in the professional context ii) the level of confidence in their ability to demonstrate each skill and iii) the opinion on the contribution of the higher education institution on their preparation in each skill. The identification and description of the 21 skills are presented in *Table 2*.

Table 2: Transversal Skills Definitions (Adapted from Vieira and Marques, 2014 (pp.184,185))

Skill	Description
Analysis and problem-solving	Identify and prioritize problems; ask the right questions to analyze various facets of a problem; contribute with ideas and/or answers to solve problems; willingness to question own's and other's ideas.
Decision-making	Decide in a timely manner based on the assessment of their consequences (e.g. implications on others, political and/or ethical aspects); responsibility for the decisions taken.
Planning and organization	Define the tasks necessary to achieve the objectives outlined; delegate tasks by monitoring progress according to plan; update it against unforeseen circumstances.
Time management	Manage multiple tasks at once; be on time; be able to set priorities and make time efficiently meaningless to meet deadlines.
Risk-taking	Take moderate risks; opt for alternative ways of achieving objectives by being aware of the potential consequences.
Oral communication	Present clear verbal information to others individually, in groups or in public; express their opinions and defend their rights respecting each other.
Active listening	Listen carefully to others; respond appropriately to others during conversations/meetings; in case of doubt, make sure you are understanding the other's message correctly.

Written communication	Write correctly formal (e.g., reports, correspondence, emails) or informal documents (for example, memos, notes).
Interpersonal relationships and conflict management	To relate positively with the others, enhancing the achievement of labor objectives; Identify sources of confidence and act in the sense of its resolution.
Leadership	Orient others' work and delegate tasks; motivate others to give their best; Identify and develop others' strengths to achieve common goals; Encourage positive group relationships.
Creativity and Innovation	Create new solutions or ideas; demonstrate originality and creativity; suggest new proposals to innovative.
Flexibility and Adaptation	Deal well with contingencies; adapt to situations of change; work well under stress; Respond properly to constructive criticism.
Lifelong Learning	Acquire knowledge from everyday experience; learn from own mistakes; Continually making updates in the working area.
Ability to conceptualize	Combine information from various sources; Integrate the knowledge from various areas; integrate information in more general contexts; collect, systematize and process information.
Teamwork	To contribute actively to a group with a view to achieving a common goal, sharing resources and responsibilities; encourage the participation of all members of the group.
Striving for Excellence	Maintain a positive attitude and be persistent in the face of difficulties; be proactive in pursuit of continuous improvement; Be aware of the provisions without losing sight of the ultimate goal.
Diversity and multiculturality	Facility for working in collaboration with individuals from different cultures, races, ages, religions, lifestyles and points of view; know and respect intercultural differences.
Ethics and social responsibility	Show integrity, ethical behavior and loyalty; Act with responsibility in the interests of the community.
Information and communication technologies	Select and use the right technology to accomplish each task; use the computer skillfully by adapting to new applications/computer software; agility in the use of other electronic equipment (e.g. tablet, video projectors, printers) and the internet.

Proficiency in foreign languages	Use foreign languages fluently for written and oral communication.
Field-specific skills	Mobilize theoretical and practical knowledge of specific knowledge area.

Therefore, our primary goals are to understand if there are any statistical differences among usage, preparation and confidence within this skill set by different CNAEF groups, namely, social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction). Consequently, our hypotheses are the following:

> H1: There are statistically significant differences between social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) in terms of transversal skills usage in their daily work life;
>
> H2: There are statistically significant differences between social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) in terms of transversal skills confidence;
>
> H3: There are statistically significant differences between social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) related to the preparation of transversal skills given by HEI.

The methodological approach used to meet the objectives of the present study is quantitative (Mark, Philip, & Adrian, 2009). The statistical package for the social sciences SPPS IBM (version 25) statistics will be used for data analysis. IBM SPSS allows the statistical analysis of data, generating detailed tabulated reports, descriptive statistics, and sophisticated statistical analysis. Also, SPSS can provide an in-depth analysis such as ANOVA (Analysis of variance), MANOVA (Multivariate analysis of variance) and *post hoc* tests such as Tukey Test (Chandler, 2014).

The analysis of Likert-type responses allows us to make a set of statistical analyses, such as the analysis of variance, which presuppose metric variables (Marôco, 2010). In order to test the three hypotheses described above, several MANOVAs will be performed. Specifically, Wilks's lambda (Λ) will be the statistical test that will be conducted to reject or not the hypothesis. We could use others, such as Pillai's Trace, Hotelling's Trace or Roy's Largest Root but Wilks' lambda is the most prominent of

these tests in the research literature. In MANOVA analyses, Wilks' lambda test is used to know the overall significance of the model. Once the overall model is significant, then it is possible to predict the individual significance of each variable (Joseph, Black, Babin, & Anderson, 2010). For this purpose, a *post hoc* analysis, namely the Tukey test will be made (Pestana & Gageiro, 2008).

It is important to mention that in this study a level of significance of 0,05 was considered (Field, 2013). The *p* value represents the probability value or significance, which support, or not, the inferred hypotheses under a significance level less than α. When the value is less than α means the null hypothesis is considered to be rejected (Levine & Hullett, 2002).

In the "Prepared to work?" project (Vieira & Marques, 2014), the data collection procedures were the following: the link to the online questionnaire was made available to the higher education institutions and each of them was responsible for contacting and inviting the respective graduates to participate in the project and answer the online questionnaire. The data collection was undertaken between February and June of 2014. The questionnaire was held in Portuguese and can be consulted in detail in Annex I, as well as the explanation of its purpose and what was asked of the respondents.

3.3 Sample Profile and analysis of the data collection

The sample of the present study is composed by 768 working graduates from a higher education institution in the northern part of Portugal. Participants´ sociodemographic characteristics such as gender, age and knowledge area are presented in *Table 3*.

Table 3: Descriptive Statistics for sociodemographic variables used in research

		Frequency	Percentage	Cumulative Percentage
Gender	Male	360	46,9%	46,9%
	Female	408	53,1%	100%
Age	<=26	245	31,9%	31,9%
	27-28	167	21,7%	53,6%
	29-31	199	25,9%	79,6%
	32+	157	20,4%	100%
Knowledge area	Social sciences, Commerce and Law Sciences	350	45,6%	45,6%
	Mathematics and Informatics	178	23,2%	68,8%

Engineering Manufacturing and Construction	240	31,3%	100%

Source: Own elaboration

As can be seen from the analysis in Table 3, the sample of 768 graduates is mostly female (53.1%) and a mean age of 29 years (standard deviation ± 5 years). Almost half of the participants studied Social Sciences, commerce and law (45.6%), which accounts 350 of the participants, 178 studied Science, Mathematics and Informatics (23.2%) and 240 Engineering, Manufacturing and Construction (31.3%).

4. Results and discussion

In this chapter, the author will present the results obtained in this study, discussing and interpreting them in light of the theoretical assumptions analyzed, always considering the defined objectives for this study as guidelines for data analysis.

4.1 Level of usage of transversal skills in the professional context

Regarding the means and standard deviations by comparing different transversal skills on the different three main knowledge areas, as can be seen in *Table 4*, the means for the Social Sciences, Commerce and Law trade vary between 3.30 and 4.21. For Science, Mathematics and Informatics the average varies between the values 3.42 and 4.34, and for Engineering, Manufacturing and Construction the average varies between the values 3.25 and 4.35. In general, all the knowledge areas showed that all skills are used in medium or high grade, when asked to graduates to indicate the degree of utilization of each skill on a 5-point Likert scale (1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high).

The descriptive statistics show differences between the skills most used by each knowledge area. For the group of Social Sciences, Commerce and Law, the most commonly used skills are analysis and problem-solving, planning and organization, time management, oral communication, active listening and interpersonal relationships and conflict management. For Sciences, Mathematics and Informatics, the most used skills by graduates are analysis and problem-solving, flexibility and adaptation, lifelong learning, teamwork, information and communication technologies and field-specific skills. For Engineering, Manufacturing and Construction analysis and problem-solving, flexibility and adaptation, lifelong learning, teamwork, information and communication technologies and field-specific skills are the most used skills.

It can be stated, from the descriptive analysis in *Table 4*, that regardless of the knowledge area, graduates attribute a higher level of use in the workplace for analysis and problem-solving.

Table 4: Means and standard deviations to the level of use of transversal skills in the professional context by knowledge areas

Skills	Social Sciences, Commerce and Law		Sciences, Mathematics and Informatics		Engineering, Manufacturing and Construction	
	M	SD	M	SD	M	SD
Analysis and problem-solving	4,17	0,871	4,34	0,764	4,35	0,811
Decision-making	3,81	1,026	3,84	0,983	3,94	0,923
Planning and organization	4,16	0,989	3,99	0,961	4,02	0,981
Time management	4,14	0,935	4,00	0,917	4,06	0,928
Risk-taking	3,40	1,100	3,50	1,052	3,59	1,008
Oral communication	4,18	0,901	3,84	0,922	3,75	0,957
Active listening	4,21	0,824	3,94	0,911	3,76	0,933
Written communication	4,06	0,984	3,82	0,968	3,74	1,001
Interpersonal relationships and conflict management	4,13	0,909	3,93	0,930	3,79	1,079
Leadership	3,36	1,168	3,42	1,119	3,25	1,142
Creativity and Innovation	3,35	1,062	3,81	0,971	3,70	1,000
Flexibility and Adaptation	4,05	0,874	4,16	0,869	4,13	0,833
Lifelong Learning	3,94	0,947	4,19	0,825	4,17	0,910
Ability to conceptualize	3,69	1,008	4,03	0,805	3,97	0,920
Team work	4,06	0,954	4,27	0,745	4,16	0,961
Striving for Excellence	3,92	1,068	4,06	0,926	4,00	0,918
Diversity and multiculturality	3,55	1,161	3,74	1,031	3,65	1,143
Ethics and social responsibility	3,93	1,051	3,99	0,887	3,72	1,020
Information and communication technologies	4,00	0,979	4,16	0,940	4,19	0,945
Proficiency in foreign languages	3,30	1,191	3,68	1,162	3,77	1,208
Field-specific skills	3,83	1,076	4,23	0,885	4,22	0,982

Regarding the first hypothesis concerning "There are statistically significant differences between social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) in terms of transversal skills usage in their daily work life", at a multivariate level statistically significant differences were identified using a Multivariate MANOVA. The Wilks' Lambda shows that there is a statistically significant effect of knowledge areas - $F_{(42, 1320)} = 4.568$, $p < 0.001$. *Table 9* (see Annex II) presents multivariate analysis of

variance (MANOVA) to understand if there is an interaction between the set of the 21 skills (dependent variables) and knowledge areas. Multivariate MANOVAs on the outcome variables revealed that knowledge areas (Social sciences, commerce and law; sciences, mathematics and informatics and engineering, manufacturing and construction) had a significant effect on the analysis and problem-solving ($F_{(2,680)}$ = 3,886, p = 0,021), oral communication ($F_{(2,680)}$ = 16,137, p < 0,001) , active listening ($F_{(2,680)}$ = 17,187, p < 0,001), written communication ($F_{(2,680)}$ = 17,187, p < 0,001), interpersonal relationships and conflict management ($F_{(2,680)}$ = 8,335, p <0,001), creativity and innovation ($F_{(2,680)}$ = 13,245, p < 0,001), lifelong learning ($F_{(2,680)}$ = 5,599, p = 0,004), ability to conceptualize ($F_{(2,680)}$ = 9,169, p <0,001), ethics and social responsibility ($F_{(2,680)}$ = 3,972, p = 0,019), proficiency in foreign languages ($F_{(2,680)}$ = 11,515, p <0,001), and field-specific skills ($F_{(2,680)}$ = 11,515, p <0,001).

It is true that there is a statistical significance difference between some soft skills among different knowledge areas. In order to further specify the significant differences among the knowledge areas, we conducted *post hoc* tests, in this case, post hoc Tukey HSD tests (Olleveant, 1999). The Tukey post hoc test, on the following *Table 10* (see Annex II), will provide greater insight into the differences or similarities between the specific groups and is, therefore, an important step in data analysis.

The multiple comparisons between the Social Sciences, Commerce and Law and Sciences, Mathematics and Informatics revealed statistically significant differences between the following skills: oral communication (p<0,01, d=0,34), active listening (p< 0,01, d=0,27), written communication (p< 0,05, d=0,24), creativity and innovation (p< 0,01, d=-0,46), lifelong learning (p< 0,05, d=-0,25), ability to conceptualize (p<0,01, d=-0,34), proficiency in foreign languages (p<0,01, d=-0,38). Based on the means observed in Table 4 and comparing both groups, we conclude that the group of Social Sciences, Commerce and Law present higher levels of use of oral communication, active listening, written communication while Sciences, Mathematics and Informatics presents higher level of use of creativity and innovation, lifelong learning, ability to conceptualize and proficiency in foreign languages.

The multiple comparisons between the Social Sciences, Commerce and Law and Engineering, Manufacturing and Construction, according to Tukey revealed statistically significant differences between the following skills: analysis and problem-solving (p<0,05, d= -0,18), oral communication (p<0,01, d=0,44), active listening (p<0,01, d=0,44), written communication (p< 0,01, d=0,32), interpersonal relationships and conflict management (p<0,01, d=0,34), creativity and innovation (p< 0,01, d=-0,35), lifelong learning (p<0,05, d=-0,22), ability to conceptualize (p<0,01, d= -0,28), ethics and social responsibility (p<0,05, d=0,21), proficiency in foreign languages (p<0,01, d=-0,47), field-specific skills (p<0,01, d=-0,40). The group of Engineering, Manufacturing, and Construction reported

higher levels of use on analysis and problem-solving, creativity and innovation, lifelong learning, proficiency in foreign languages and field-specific skills when compared to Social Sciences, Commerce and Law. However, skills related to general communication skills such as oral communication, active listening, written communication, interpersonal relationships and conflict management presented higher levels of use by the Social Sciences, Commerce and Law group.

The multiple comparisons between Sciences, Mathematics and Informatics, and Engineering, Manufacturing and Construction, according to Tukey test revealed statistically significant differences only on ethics and social responsibility (p<0,05, d=0,27), where Sciences, Mathematics and Informatics presents a higher level of use when compared to Engineering, Manufacturing and Construction.

Not surprisingly, when comparing the STEM groups, the differences between them are much weaker than the differences between these two groups and the Social Sciences, Commerce and Law group.

4.2 Level of confidence of transversal skills on the professional context

As can be seen in *Table 5*, the means for levels of confidence for the set of 21 transversal skills vary according to the different knowledge areas. For Social Sciences, Commerce and Law trade the means vary between 3.50 and 4.26. For Science, Mathematics and Informatics the average varies between the values 3.60 and 4.33, and for Engineering, Manufacturing and Construction the average varies between the values 3.61 and 4.38.

In general, all the knowledge areas showed levels of confidence of medium or high grade, since the majority reported a mean score > 3 and graduates were asked to indicate the degree of confidence to demonstrate each skill on a Likert-type scale of 5 points (1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high).

In terms of descriptive statistics, there are differences between the skills that present higher levels of confidence according to each group. For the Social Sciences, Commerce and Law group, the skills that present higher levels of confidence are active listening, written communication, lifelong learning, teamwork, ethics and social responsibility and information and communication technologies. For Sciences, Mathematics and Informatics, the skills with higher levels of confidence are flexibility and adaptation, lifelong learning, teamwork, striving for excellence, ethics and social responsibility and information and communication technologies. On the other hand, analysis and problem-solving, flexibility and adaptation, lifelong learning, teamwork, striving for excellence and information and communication technologies are the skills

that present higher levels of confidence for Engineering, Manufacturing and Construction.

It can be affirmed, through the analysis of *Table 5*, that the variables that, independently of the knowledge area, graduates attribute a higher level of confidence are lifelong learning, teamwork and information and communication technologies.

Table 5: Means and standard deviations of the level of confidence to demonstrate transversal skills by knowledge areas

Skills	Social Sciences, Commerce and Law		Sciences, Mathematics and Informatics		Engineering, Manufacturing and Construction	
	M	SD	M	SD	M	SD
Analysis and problem-solving	3,96	0,784	4,11	0,751	4,11	0,712
Decision-making	3,80	0,861	3,84	0,822	3,82	0,813
Planning and organization	4,13	0,782	3,93	0,841	4,05	0,819
Time management	3,93	0,896	3,89	0,876	3,91	0,863
Risk-taking	3,50	0,939	3,69	0,884	3,64	0,857
Oral communication	4,06	0,851	3,85	0,810	3,80	0,944
Active listening	4,23	0,737	4,11	0,717	4,03	0,797
Written communication	4,21	0,754	4,01	0,792	4,01	0,789
Interpersonal relationships and conflict management	4,07	0,807	3,99	0,802	4,04	0,802
Leadership	3,63	0,954	3,60	0,999	3,61	0,987
Creativity and Innovation	3,58	0,920	3,79	0,795	3,85	0,827
Flexibility and adaptation	4,07	0,832	4,20	0,752	4,14	0,761
Lifelong Learning	4,19	0,839	4,33	0,685	4,27	0,762
Ability to conceptualize	3,85	0,842	4,04	0,696	4,00	0,792
Teamwork	4,22	0,778	4,33	0,750	4,33	0,706
Striving for excellence	4,06	0,922	4,16	0,801	4,16	0,783
Diversity and multiculturality	3,94	0,925	4,04	0,826	4,10	0,879
Ethics and social responsibility	4,26	0,861	4,22	0,790	4,12	0,825
Information and communication technologies	4,14	0,824	4,25	0,758	4,38	0,738
Proficiency in foreign languages	3,55	1,011	3,67	1,001	3,80	0,938
Field-specific skills	3,91	0,860	4,08	0,813	4,10	0,775

Regarding the second hypothesis concerning "There are statistically significant differences between Social Sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) in terms of transversal skills confidence", some statistically significant differences were identified using MANOVA and the Wilks' Lambda test. There is a statistically significant multivariate effect of knowledge area - $F_{(42, 1490)} = 3.822$, $p < 0.001$. *Table 11* (see Annex II) presents the results that allow to understand if there are mean differences among the groups on the confidence level reported the set of the 21 skills (dependent variables). Results revealed that knowledge areas (Social sciences, Commerce and Law; Sciences, Mathematics and Informatics and Engineering, Manufacturing and Construction) had a significant effect on analysis and problem-solving ($F_{(2,765)} = 3,915$, $p = 0,020$), planning and organization ($F_{(2,765)} = 3,510$, $p = 0,030$), oral communication ($F_{(2,765)} = 7,578$, $p=0,001$), active listening ($F_{(2,765)} = ,030$, $p = 0,002$), written communication ($F_{(2,765)} = ,030$, $p = 0,002$), creativity and innovation ($F_{(2,765)} = 7,461$, $p = 0,001$), ability to conceptualize ($F_{(2,765)} = 4,698$, $p = 0,009$), information and communication technologies ($F_{(2,765)} = 6,288$, $p = 0,002$), proficiency in foreign languages ($F_{(2,765)} = 6,288$, $p = 0,002$) and field-specific skills ($F_{(2,765)} = 4,559$, $p = 0,011$).

The Tukey test of multiple comparisons on *Table 12* (see Annex II) was computed to analyze in detail the significances of the pairwise comparisons since "knowledge area" is the independent factor and is composed by 3 groups (Field, 2013).

The multiple comparisons between the Social Sciences, Commerce and Law and Sciences, Mathematics and Informatics, according to Tukey test revealed statistically significant differences in confidence levels between the following skills: planning and organization ($p< 0,05$, d= 0,20), oral communication ($p<0,05$, d=0,21), written communication ($p< 0,05$, d=0,21), creativity and innovation ($p< 0,01$, d=-0,20), ability to conceptualize ($p<0,01$, d=-0,20). By observing the means values presented in Table 5, we may conclude that the group of Social Sciences, Commerce and Law presents higher levels of confidence on planning and organization, the use of oral communication and written communication when compared to Sciences, Mathematics and Informatics. On the other hand, higher levels of confidence on creativity and innovation, and ability to conceptualize were reported by Sciences, Mathematics and Informatics graduates.

The multiple comparisons between the Social Sciences, Commerce and Law and Engineering, Manufacturing and Construction, according to Tukey revealed statistically significant differences between the following skills: analysis and problem-solving ($p<0,05$, d= -0,15), oral communication ($p<0,01$, d=0,27), active listening ($p< 0,01$, d=0,20), written communication ($p< 0,01$, d=0,20), creativity and innovation ($p< 0,01$, d=-0,26), information and communication technologies ($p<0,01$, d=-0,23), proficiency in foreign languages ($p<0,05$,d=-0,25) and, field-specific skills ($p<0,05$,d=-0,19). The group

of Engineering, Manufacturing, and Construction related higher levels of confidence on the use of skills such as analysis and problem-solving, creativity and innovation, information and communication technologies, proficiency in foreign languages and field-specific skills when compared to Social Sciences, Commerce and Law. However, this last group presents a higher level of confidence in oral communication, active listening and written communication.

Finally, regarding the confidence levels of the two areas that belong to the STEM groups, no significant differences were found in any transversal skill. Again, this result reinforces the greater similarity between Engineering, Manufacturing, and Construction, and, Sciences, Mathematics and Informatics graduates' groups, when both compare to the graduates from the Social Sciences, Commerce and Law group.

4.3 Level of preparation by HEI of transversal skills to the professional context

As can be seen in *Table 6*, when asked to graduates to indicate the degree of preparation given by HEI of each skill on a 5-point Likert scale (1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high), the average values relative to the preparation given by HEI are differentiated according to the different knowledge areas. For the Social Sciences, Commerce and Law trade vary between 2.91 and 3.85. For Science, Mathematics and Informatics the average varies between the values 3.05 and 4.01 and for Engineering, Manufacturing and Construction the average varies between the values 2.94 and 4.09.

In terms of descriptive statistics, there are differences between the skills with higher preparation given by HEI by knowledge area. Graduates from the Social Sciences, Commerce and Law present higher means values for oral communication, active listening, written communication, teamwork, ethics and social responsibility and field-specific skills. For the Science, Mathematics and Informatics graduates, the skills with higher preparation given by HEI are analysis and problem-solving, lifelong learning, teamwork, striving for excellence, information and communication technologies and field-specific skills. Finally, for Engineering, Manufacturing and Construction, analysis and problem-solving, lifelong learning, ability to conceptualize, teamwork, information and communication technologies and field-specific skills are the skills that represent a higher level of preparation given by HEI.

It can be affirmed from the analysis in *Table 6*, regardless of the knowledge area, a high level of preparation by Higher Education Institutions was reported to teamwork and field-specific skills.

Table 6: Means and standard deviations of the level of preparation given by HEI of transversal skills for the professional context by knowledge areas

Skills	Social Sciences, Commerce and Law		Sciences, Mathematics and Informatics		Engineering, Manufacturing and Construction	
	M	SD	M	SD	M	SD
Analysis and problem-solving	3,36	0,994	3,80	0,870	3,80	0,844
Decision-making	3,12	1,028	3,37	0,943	3,28	0,978
Planning and organization	3,52	0,980	3,62	0,950	3,56	0,949
Time management	3,35	1,048	3,50	1,010	3,27	1,093
Risk-taking	2,91	1,029	3,14	1,067	2,94	1,043
Oral communication	3,69	1,000	3,42	1,045	3,37	1,058
Active listening	3,71	0,998	3,56	0,980	3,39	1,037
Written communication	3,85	0,929	3,56	1,008	3,56	0,975
Interpersonal relationships and conflict management	3,48	1,037	3,35	1,090	3,34	1,010
Leadership	3,09	1,110	3,05	1,121	2,94	1,092
Creativity and Innovation	3,17	1,041	3,48	1,004	3,58	0,930
Flexibility and adaptation	3,45	1,002	3,63	0,955	3,70	0,907
Lifelong Learning	3,51	1,062	3,94	0,934	3,83	0,896
Ability to conceptualize	3,63	0,920	3,70	0,906	3,73	0,945
Team work	3,81	0,985	3,99	0,873	4,09	0,774
Striving for Excellence	3,63	1,054	3,72	0,957	3,69	0,971
Diversity and multiculturality	3,55	1,063	3,37	1,087	3,50	0,959
Ethics and social responsibility	3,67	1,035	3,38	1,100	3,40	1,017
Information and communication technologies	3,41	1,072	4,01	1,008	3,99	0,873
Proficiency in foreign languages	3,11	1,152	3,07	1,162	3,05	1,075
Field-specific skills	3,78	0,952	3,98	0,948	3,97	0,884

Regarding the third hypothesis concerning “There are statistically significant differences between social sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) related to the preparation of transversal skills given by HEI”, some statistically significant differences were identified using MANOVA and the Wilks' Lambda test. There is a statistically significant multivariate effect of knowledge areas - F

$_{(42, 1490)}$ = 7.129, p < 0.001. *Table 13* (see Annex II) presents results from the analysis of variance which allow to understand if there are mean differences between the 21 skills in terms of the level of preparation given by HEI. Results revealed that knowledge areas (Social Sciences, Commerce and Law; Sciences, Mathematics and Informatics and Engineering, Manufacturing and Construction) had a significant effect on analysis and problem-solving ($F_{(2,765)}$ = 21,873, p <0,001), decision-making ($F_{(2,765)}$ = 4,277, p =0,014), oral communication ($F_{(2,765)}$ = 8,322, p <0,001), active listening ($F_{(2,765)}$ =7,212, p = 0,001), written communication ($F_{(2,765)}$ = 8,442, p <0,001), creativity and innovation ($F_{(2,765)}$ = 13,722, p = 0,035), flexibility and adaptation ($F_{(2,765)}$ = 5,041, p = 0,007), lifelong learning ($F_{(2,765)}$ = 13,896, p <0,001), teamwork ($F_{(2,765)}$ = 6,991, p =0,001), ethics and social responsibility ($F_{(2,765)}$ = 6,783, p = 0,001), information and communication technologies ($F_{(2,765)}$ = 33,114, p <0,001) and field-specific skills ($F_{(2,765)}$ = 4,362, p = 0,013).

From *Table 14* (see Annex II), it can be seen that, all *post hoc* comparisons for the eleven skills identified in *Table 13* (see Annex II) are statistically significant (p < 0,05) based on Tukey Test. the multiple comparisons between the Social Sciences, Commerce and Law and Sciences, Mathematics and Informatics , according to Tukey revealed statistically significant differences between the following skills: analysis and problem-solving (p<0,01, d= -0,44), decision-making (p<0,05, d=-0,25), oral communication (p<0,05, d=0,27), active listening (p< 0,01, d=0,32), written communication (p< 0,01, d=0,29), creativity and innovation (p< 0,01, d=-0,32), lifelong learning (p<0,01, d=-0,43), ethics and social responsibility (p<0,01, d=0,29), information and communication technologies (p<0,01, d=-0,60), field-specific skills (p<0,05, d=-0,21). Sciences, Mathematics and Informatics perceive that HEI gives them a better preparation on analysis and problem-solving, decision-making, flexibility and adaptation, creativity and innovation, lifelong learning, teamwork, information and communication technologies and field-specific skills than Social Sciences, Commerce and Law, except for oral communication, active listening, written communication and ethics and social responsibility.

The multiple comparisons between the Social Sciences, Commerce and Law and Engineering, Manufacturing and Construction, according to Tukey revealed statistically significant differences between the following skills: analysis and problem-solving (p<0,01, d= -0,44), oral communication (p<0,01, d=,032), active listening (p< 0,01, d=0,32), written communication (p< 0,01, d=0,29), flexibility and adaptation (p<0,01, d=-0,24), creativity and innovation (p< 0,01, d=-0,41), teamwork (p<0,01, d=-0,27), information and communication technologies (p<0,01, d=-0,58), field-specific skills (p<0,05,d=-0,19). Engineering, Manufacturing, and Construction graduates perceive that HEI gives them a better preparation on analysis and problem-solving, flexibility and adaptation, creativity and innovation, teamwork, information and communication

technologies, and, field-specific skills than Social Sciences, Commerce and Law graduates, except for oral communication, active listening and written communication.

4.4 Summary of the main results

In order to summarize the main results related to the level of usage, confidence and preparation received from HEI regarding transversal skills, by knowledge area, the results with statistically significant differences are systematized in *Table 7*.

Table 7: Summary of transversal skills: Mean differences among Social Sciences, Commerce and Law (SS), Sciences, Mathematics and Informatics (MI) and Engineering, Manufacturing and Construction (EM).

Skill	Usage	Confidence	Preparation
Analysis and problem-solving	SS < EM	SS < EM	SS < MI, EM
Decision-making	-	-	SS < MI
Planning and organization	-	SS > MI	-
Time management	-	-	-
Risk-taking	-	-	-
Oral communication	SS > MI, EM	SS > MI, EM	SS > MI, EM
Active listening	SS > MI, EM	SS > EM	SS > MI, EM
Written communication	SS > MI, EM	SS > MI, EM	SS > MI, EM
Interpersonal relationships and conflict management	SS > EM	-	-
Leadership	-	-	-
Creativity and Innovation	SS < MI, EM	SS < MI, EM	SS < MI, EM
Flexibility and adaptation	-	-	SS < MI, EM
Lifelong Learning	SS < MI, EM	-	SS < MI
Ability to conceptualize	SS < MI	SS < MI	-
Teamwork	-	-	SS < MI, EM
Striving for excellence	-	-	-
Diversity and multiculturality	-	-	-
Ethics and social responsibility	MI > EM	-	SS > MI
Information and Communication technologies	-	SS < EM	SS < MI, EM
Proficiency in foreign languages	SS < MI, EM	SS < EM	-
Field-specific skills	SS < EM	SS < EM	SS < MI, EM

Note: "-" = no differences; SS= Social Sciences, Commerce and Law; MI= Sciences, Mathematics and Informatics; EM=Engineering, Manufacturing and Construction.

4.5 Discussion

This study revealed statistically significant differences between the group of Social Sciences (Social Sciences, Commerce and Law) and STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) in terms of graduates' transversal skills usage and confidence in their daily work life and preparation given by HEIs (H1, H2 and H3). However, the results found in this work, with the Tukey post hoc test, were not consistent with what it was found in our literature review, including the work of Chamorro-Premuzic et al. (2010, p. 221) where " examination of mean differences across faculties (humanities, life sciences, hard sciences) revealed higher soft skills ratings in 'softer' courses". In the present study we found that, with the exception of oral communication, active listening, written communication, and ethics and social responsibility, STEM groups (Sciences, Mathematics and Informatics; Engineering, Manufacturing and Construction) reported a higher level of preparation given by HEI in a higher number of transversal skills than Social Sciences (Social Sciences, Commerce and Law), which indicates that in the Portuguese context, there seems to exist a divergence related to the teaching of transversal skills between the subjects of Social Sciences and STEM, where this last group seems to have benefited more by the teaching of transversal skills.

Analysis and problem-solving reported a high average preparation given by HEIs on both two areas that belong to the STEM groups when compared to Social Sciences. However, from *Table 4* and *Table 6*, when analyzed in isolation the group of Social Sciences, it is observed that this skill presents a high average value on use and a lower mean value of preparation given by HEI. The importance of this skill has been highlighted by several different kinds of literature and recently was ranked by the World Economic Forum as a skill which all universities should have present in their curriculum by 2020 across all knowledge areas (Eberhard et al., 2017; World Economic Forum, 2018).

The expected trend of flatter organizations structures with the fourth industrial revolution is likely to boost the odds of employee participation in discussions and decision making (Shamim et al., 2016, July). Despite the amount of dedication given by the university to decision making skill do not match with corporate demands (Pereira, 2013), it is considered as a "required" skill by engineering graduates by employers (Yuzainee, Zaharim, & Omar, 2011, April), which can be interpreted as an explanation to why, on this study, the group of "Sciences, Mathematics and Informatics" has received a better preparation by HEI on this skill than their counterparts of Social Sciences, Commerce and Law.

The ability to strategically deal with challenges is one of the key conditions for the success of the "Fourth Revolution" and the increasing uncertainty and complexity

about organizational variables that Industry 4.0 brings, indicates predictably an increasing proportion of employees involved in planning and control roles, that are normally associated to managing positions (Leonhardt & Wiedemann, 2015; Witkowski, 2017; World Economic Forum, 2018). On this dissertation planning and organization showed higher levels of confidence by Social Sciences than the group of Sciences, Mathematics and Informatics.

Oral communication, active listening, and written communication showed a higher level of use, confidence and preparation given by HEI by Social Sciences than the subjects in both areas that belong to STEM groups, which is in agreement with what was found on Pereira and Costa (2017, p. 9) where “statistically significant differences of greater appreciation on communication variables by Law and International Business students as opposed to Engineering students”. Yuzainee et al. (2011, April) show that employers consistently cited communication skills such as “Speak in clear sentences”, “Present ideas confidently and effectively” and “Listen and ask question” having a huge importance for engineers. However, previous studies show a high level of weakness in these skills among local engineer graduates. Since flatter organizational structures are expected, horizontal communication will need to be increasingly more effective between employees, in order to implement quick changes with the change in the business environment. Collaboration and effective communication skills to pick up the benefits of smart manufacturing must be part of an organizational routine to facilitate peer interactions that fuel innovation and it is necessary across all roles (Azmi et al., 2018; Shamim et al., 2016, July; Williams, 2003).

Creativity and Innovation appear as skills with more confidence, use and level of preparation on both areas that belong to STEM groups, which seems to be in agreement with Dias and Soares (2018, September, p. 238) where innovation is “emphasized on programs related to manufacturing industries, closely connected to engineering and computer science areas”. As seen in the literature review, the ability to create more innovative products and services and develop new business, be creative and act as an entrepreneur, within or not existing companies will be crucial for Industry 4.0. The promotion of innovation should be part of the organizational routine, "by developing the innovative work behavior, and enhancing the knowledge management practices in the organization, which has the potential to positively influence innovativeness" (Shamim et al., 2016, July, p. 5313).

The globalized economy, the increase of virtual work will require globalized teams, and workers will need to adapt to new collaborations, new resources, and new deadlines. A sophisticated portfolio of effective communication, ability to work with people from different backgrounds, manage conflicts will have key importance (Eberhard et al., 2017; Pompa, 2015). Our results suggest that interpersonal relationships and

conflict management are more used by the group of Social Sciences than the Engineering, Manufacturing and Construction field, and it can be explained, as seen in the literature review because the development of soft and hard skills depends on several factors such as the professional role (Nilsson, 2010). For example, on roles such as an entry-level manager, organizations tendentiously look for emotional resiliency, and for interpersonal skills (Yasin et al., 2009) that seem to be directly necessary for work performance (Nilsson, 2010).

Industry 4.0 is characterized for being knowledge-based, requiring intensive and consistent use of new skills, higher education systems police should ensure the ability for lifelong learning. New forms of lifelong learning, new methods of working, such as virtual work, and adding to that the newer generations are more likely to change their job several times, flexibility and adaptability will be essential skills for the modern worker (Eberhard et al., 2017; Pompa, 2015). From our research, the STEM groups are perceived to be relatively better prepared by HEI in terms of flexibility and adaptation than the Social Sciences' group. Moreover, when compared to the Social Sciences group, the skill of lifelong learning seems to be better prepared by the HEI on the group of Sciences, Mathematics and Informatics, as well as to have a higher usage on both areas that belong to STEM groups. This inference seems to be in agreement with Yuzainee et al. (2011, April) since lifelong learning is considered “required” by employers from engineering graduates.

Analysis through big data will challenge organizations to constantly managing in a quick and efficient way the growing amount of data from different sources. The ability to conceptualize should allow any individual within an organization to transfer knowledge across different sources and departments to carry out business objectives (Witkowski, 2017). From what we found on this work, it is more used and presents higher levels of confidence in Sciences, Mathematics and Informatics field than Social Sciences.

The international focus on companies to ensure competitiveness, the expected increase of global mobility and migration, the increasing trend of working virtually coupled with internationally assembled taskforces, will require multi-cultural understanding and the ability to speak foreign languages (Eberhard et al., 2017; Pompa, 2015). Teamwork is going to be inevitable, and those teams being globally spread will not be a rule exception. The increasing need for working virtually from and to all over the world makes the ability to speak foreign languages having huge importance. Also, the ability to manage and work with multi-cultural teams from different geographical regions, nationalities, and religions effectively to achieve quality results also will have a huge importance (Eberhard et al., 2017; Pompa, 2015). From our results, STEM graduates perceive to have a better preparation given by HEI than Social Sciences on teamwork’ skill, which can be explained by an increasing need of information and technology skills

where those professionals need to increase working in teams to solve conflicts and to work in peers to arrive at a common goal (Zhang, 2012). Despite these results, as found by Williams (2003) teamwork is a skill necessary across all roles. Relatively to the skill of ethics and social responsibility, the group of Social Sciences, Commerce and Law is perceived to receive a better preparation by HEI, however, the university curriculum, independently the knowledge area, needs to help to develop this skill among graduates "for awareness of societal and human impacts, and to be able to comprehend the impacts of 4IR technologies on people, so they are trained to not only increase our material prosperity but also to improve our social and cultural fabric" (Penprase, 2018, p. 225).

Digital skills are not exclusively grounded in the IT department. The workforce of the future will be required to have a high level of digital competence and to adapt to new technological developments, access, evaluate, apply and manage information and large amounts of data to produce new sources of information (Pompa, 2015; World Economic Forum, 2018). For example, "In Logistics 4.0 ICT competences will be required from specialists, managers, as well as from blue-collar workers[5]" (Wrobel-Lachowska, Wisniewski, & Polak-Sopinska, 2017, p. 406). Students from STEM groups receive a higher preparation on this skill than Social Sciences. The ability to use different software, new applications and electronic equipment is not being emphasized by higher institutions in the fields of Social Sciences – the digital skills are needed by the general workforce and despite "likely to differ across sectors, there will be some minimum requirements linked to processing information that will be applicable across all sectors" (Motyl et al., 2017, p. 1503).

In line with the findings of what Tomlinson (2007) concluded by examining the different contributions of different disciplinary fields, Social Sciences and Humanities rated less critical to the input from higher education systems to their preparation and transition to work when compared to their Engineering counterparts. In this dissertation, the field-specific skills on Social Sciences, Commerce and Law always were perceived to have, in terms of use, confidence, and preparation given by higher education institutions a less rated importance when compared to other two groups. As seen in the literature review, the STEM groups are expected to grow in terms of job demand, since "the increasing technological impact on using information and communication technology" (Eberhard et al., 2017, p. 48) demands more specialized work in areas such as computing, mathematics, engineering, especially on information and communication technology (ICT) sectors (Caruso, 2017; Ślusarczyk, 2018; Tomlinson, 2007).

In spite of the absence of differences among knowledge area in what relates to leadership skills, it seems worth to note that leadership traditionally represents low levels

[5] A blue-collar worker is a name given for a person who performs manual labor.

of preparation by HEI, and low levels of confidence, independently the knowledge area (see *Table 5* and *Table 6*). Within Industry 4.0 is, even more, expected the top-down approaches, more collaboratives ways of working and decentralized management approaches where the leadership is spread among different workers (Caruso, 2017; Karacay, 2018), which means graduates need a massive support of preparation for leadership roles in a world of rapidly accelerating change (Penprase, 2018). A survey with chief human resources and strategy officer from leading global employers, the World Economic Forum, considered leadership as the fourth most important among ten skills more critical for any work.

In this way, it can be observed that the knowledge areas have an impact on the transversal skills on the level of its use in an organization, of graduates' confidence and in their perception in which the higher education entities prepared them. As markets become increasingly competitive, through the present study, it can be suggested an improvement on the development of an engaging curriculum by HEI, at the level of transversal skills which might be a way of graduates achieve unique and competitive advantages in an Industry context 4.0. This results may suggest the universities have a responsibility, not only to provide, but also transform, the old teaching and learning methods and, move away from prepare graduates by trying to only deliver technical knowledge and, instead move into preparing graduates with the necessary transversal skills that allow them to reprogram their skillset, as well as help to mold their future work realities, that might be in a constant change.

And with this, we finally have enough support to answer the main question - "Is Portuguese higher education institutions preparing graduates for Industry 4.0 in terms of transversal skills?" Despite the expected confluence between the scope of humanities, social science together with science and technology (Xing & Marwala, 2017), we would say that several improvements are needed at the level of teaching transversal skills, especially in the Social Sciences fields. As indicated previously, employers are increasingly requiring on university curricula a better preparation on transversal skills. The HEIs curriculum needed for Industry 4.0 will need to reduce the scope between humanities and STEM to create a more integrated system of education. A more responsive curriculum where students can continually update their knowledge and reinvent themselves is needed for any particular knowledge area. Graduates "who are capable of creative insights, collaborating in diverse teams, and navigating through global cultural differences will be at an advantage in a workplace" (Penprase, 2018, p. 225). On the following Table 8, and based on the results of Table 7, where were found differences on preparation by HEI according to different knowledge areas, it is summarized the improvements that this research yielded as most necessary.

Table 8: Transversal skills improvements by knowledge area based on their importance for Industry 4.0

	Social Sciences, Commerce and Law	Sciences, Mathematics and Informatics	Engineering, Manufacturing and Construction
Analysis and problem-solving	+		
Decision-making	+		
Oral communication		+	+
Active listening		+	+
Written communication		+	+
Creativity and Innovation	+		
Flexibility and adaptation	+		
Lifelong Learning	+		
Teamwork	+		
Ethics and social responsibility		+	
Information and Communication Technologies	+		
Field-specifics skills	+		

Note: "+" = Improvements on knowledge area that this research yielded as most necessary

5. Main Conclusions, Contributions and Limitations

5.1 Conclusions and Contributions

This work can be summarized into six main steps: 1) We aimed, firstly, cover the main picture about the growing importance on organizations about the need of transversal skills among workers to achieve a competitive position; 2) Framing the importance of those skills, with the changes inherent in the context of Industry 4.0; 3) Understand the future demand of transversal skills within Industry 4.0 and their important across different sectors; 4) Understand how HEIs are responding to it; 5) Understand if there were differences among the preparation of transversal skills among different Portuguese knowledge areas; 6) Suggesting for improvements for a more equal teaching in terms of transversal skills.

Keeping this in mind, this work delved, firstly, the perception of Portuguese graduates about how confident they feel about using specific transversal skills, the level of its usage in the workplace, and understand the level of transversal skills preparation by higher education institutions. We are in a time where the transformations that Industry 4.0 can bring, will impact human being at all levels, from the work sphere to a personal level. Nowadays, companies increasingly value human capital, and the increase service-orientation puts human capital in the center of an organization, capable to demand good listening, good presentation, communication and multi-cultural skills capable to innovate and achieve competitive advantage and ensure a strong and unique position in the labor market.

Through this study, it is expected that the stakeholders, from the higher education institutions to the government, can perceive which kind of transversal skills need to reinforce mostly in the higher education curriculums taking into account the changes that may occur in the labor market. Considering the opinion of a sample of 768 graduates, this research counted with the participation of graduates from different knowledge areas, which made possible to take an overview of how they have incorporated transversal skills through university. The newer generations that even may not yet be in the university will also deal in their professional life with these changes, not forgetting that they will be the most important asset of any company, the brain of innovation, quick resolution of problems and creativity that no machine can replace.

It is, therefore, necessary, that the teaching would be more collaborative, interdisciplinary, interrogative, regardless of the knowledge areas, so that students learn to raise questions because, as Alvin Toffler affirms, "the right question is usually more important than the right answer to the wrong question". We must not forget that the world is a place where everything is in constant change. New ways of doing old things will

always come up. The “new world” of working appears with new techniques and ways of working worldwide, on teams, with a flexible work schedule, with more autonomy and flexibility and, therefore, the mission of the universities, the education provider, is precisely to prepare the graduates for these changes. “Traditional learning must be combined with modern methods of teaching, learning, evaluation and tools of the new digital technology […]. The education and training system must continue to be focused on creativity and innovation, on the development of hard and soft skills that allow personal development and the integration of graduates into the global labor market” (Cernușca, Csorba, & Cilan, 2017, pp. 39,40). In traditional universities, which focus is on field-specific skills, it is not easy to equip the students with interdisciplinary skills required for Industry 4.0, which means higher education programs and course may be updated to improve these skills. “Interactive courses, for example, support students in expanding their social skills by working with colleagues in a team as well as train students in cognitive skills, like finding creative solutions for different, and interdisciplinary cases” (Eberhard et al., 2017, p. 59)

Although it is expected that Computer Science and Engineering are the two most outstanding subject areas for Industry 4.0 framework (Liao, Deschamps, Loures, & Ramos, 2017), this revolution puts people at the center (World Economic Forum, 2018). In an environment where mass-production is possible with a high degree of specificity and customization “linked to a new breed of flexible electronics-based automation technologies” (de Andrade Régio et al., 2016, p. 24), as Henry Ford once said, “You can take my factories, burn up my buildings, but give me my people and I’ll build the business right back again”.

5.2 Limitations and suggestions for further investigations

The sample is limited to the participants of only one university, which means that it was not large enough to reach generalized conclusions about the analyzed factors.

We could not control if the impact of the number of years of experience on a company affects or not the perceptions on the levels of confidence and levels of preparation given by HEI. So, another suggestion for future research would be to have a control group made up by the number of years graduates already finished their studies to a better understanding on the effects of the knowledge areas on the perception of soft skills development.

It is also worth noting that the “Prepared to Work?” was made in 2014 by Vieira and Marques (2014), included a type of assessment based on participants perceptions. Since we are in 2019, an updated data collection could show different results. However, Vieira & Marques (2014) complemented the qualitative approach with a qualitative study

among the graduates and employers. In the present study, only quantitative data were taken into consideration. In future studies, adding a qualitative approach might provide additional information about graduates' perceptions behind the answers.

Additional research could also focus on the control of variables from distinct groups, namely in terms of age, gender, and academic level, among other sociodemographic characteristics. Thus, it could be interesting to carry out these analyzes to see if there are differences in the knowledge areas controlling for these variables. Also, a qualitative study could be done to complement this quantitative study for a specific sector, such as technology to investigate the changes in the context of the fourth industrial revolution.

Additionally, the diversity of the sample led to more global conclusions about the perception of the set of 21 skills analyzed, but not to a specific view of a particular market segment. The fact that the study only makes an overall analysis of the importance of skills to an Industry context 4.0 did not allow to capture the particularities of specific sectors of activity. Future researches in this topic could be done by analyzing particular sectors, where different attributes might be valued. In this way, it is essential to realize in each sector, which attributes most contribute to the development of a unique and robust graduate attraction.

Nonetheless, this research used an intensive stock of knowledge from the fields of social sciences and technology, using complementary views from different authors, which allow us to give significant contributions to Portuguese higher education due to its focus on making improvements of different knowledge areas curricula. We identify it as a pertinent contribution of the present work since ultimately various entities try to alert higher education institutions for an urgent change.

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7. Annexes

Annex I - Survey by questionnaire

Consórcio Maior Empregabilidade
Estudo "Preparados para trabalhar?"

A nossa Instituição de Ensino Superior faz parte do Consórcio Maior Empregabilidade que está a levar a cabo um estudo que tem como objetivo final aumentar a empregabilidade dos nossos diplomados. Neste sentido, a sua opinião é fundamental para o sucesso deste projeto. A informação recolhida é anónima e confidencial. É importante que se reporte à sua experiência pessoal, sabendo que não há respostas certas nem erradas. O tempo médio de resposta ao questionário é de 8 minutos
Muito obrigado pela sua colaboração!

COMPETÊNCIAS TRANSVERSAIS - Utilização no trabalho

Indique em que medida utiliza no seu trabalho atual (caso esteja desempregado/a, responda com base no seu último emprego) cada uma das seguintes competências, de acordo com a seguinte escala de resposta.

1= Nada 2= Pouco 3= Medianamente 4= Muito 5= Totalmente

Pode clicar no ícone "?" acima de cada competência para visualizar a respetiva definição.

	1	2	3	4	5
ANÁLISE E RESOLUÇÃO DE PROBLEMAS	❑	❑	❑	❑	❑

	1	2	3	4	5
TOMADA DE DECISÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
PLANEAMENTO E ORGANIZAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
GESTÃO DE TEMPO	❑	❑	❑	❑	❑

	1	2	3	4	5
ASSUNÇÃO DO RISCO	❑	❑	❑	❑	❑

	1	2	3	4	5
EXPRESSÃO ORAL	❑	❑	❑	❑	❑

	1	2	3	4	5
ESCUTA ATIVA	❑	❑	❑	❑	❑

	1	2	3	4	5
COMUNICAÇÃO ESCRITA	❑	❑	❑	❑	❑

	1	2	3	4	5
RELACIONAMENTO INTERPESSOAL E GESTÃO DE CONFLITOS	❑	❑	❑	❑	❑

	1	2	3	4	5
LIDERANÇA	❑	❑	❑	❑	❑

Lembre-se que estas questões referem-se ao grau em que utiliza cada competência no seu trabalho atual ou último emprego (caso esteja desempregado/a) sendo que:1= Nada 2= Pouco 3= Medianamente 4= Muito 5= Totalmente

	1	2	3	4	5
CRIATIVIDADE E INOVAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
ADAPTAÇÃO E FLEXIBILIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
APRENDIZAGEM AO LONGO DA VIDA	❑	❑	❑	❑	❑

	1	2	3	4	5
CAPACIDADE DE CONCEPTUALIZAR	❑	❑	❑	❑	❑

	1	2	3	4	5
TRABALHO EM EQUIPA	❑	❑	❑	❑	❑

	1	2	3	4	5
MOTIVAÇÃO PARA A EXCELÊNCIA	❑	❑	❑	❑	❑

	1	2	3	4	5
DIVERSIDADE / MULTICULTURALIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
ÉTICA E RESPONSABILIDADE SOCIAL	❑	❑	❑	❑	❑

	1	2	3	4	5
UTILIZAÇÃO DE NOVAS TECNOLOGIAS DA INFORMAÇÃO E DA COMUNICAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
DOMÍNIO DE LÍNGUAS ESTRANGEIRAS	❑	❑	❑	❑	❑

	1	2	3	4	5
COMPETÊNCIAS TÉCNICAS DA ÁREA ESPECÍFICA DE CONHECIMENTO	❑	❑	❑	❑	❑

COMPETÊNCIAS TRANSVERSAIS - Grau de Confiança

Indique o grau de confiança que sente face à sua capacidade atual para desempenhar cada uma das atividades abaixo apresentadas, de acordo com a seguinte escala de resposta:

1= Nada Confiante 2= Um pouco confiante 3= Confiante 4= Muito Confiante 5= Totalmente Confiante

Pode clicar no ícone "?" acima de cada competência para visualizar a respetiva definição.

	1	2	3	4	5
ANÁLISE E RESOLUÇÃO DE PROBLEMAS	❑	❑	❑	❑	❑

	1	2	3	4	5
TOMADA DE DECISÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
PLANEAMENTO E ORGANIZAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
GESTÃO DO TEMPO	❑	❑	❑	❑	❑

	1	2	3	4	5
ASSUNÇÃO DO RISCO	❑	❑	❑	❑	❑

	1	2	3	4	5
EXPRESSÃO ORAL	❑	❑	❑	❑	❑

	1	2	3	4	5
ESCUTA ATIVA	❑	❑	❑	❑	❑

	1	2	3	4	5
COMUNICAÇÃO ESCRITA	❑	❑	❑	❑	❑

	1	2	3	4	5
RELACIONAMENTO INTERPESSOAL E GESTÃO DE CONFLITOS	❑	❑	❑	❑	❑

	1	2	3	4	5
LIDERANÇA	❑	❑	❑	❑	❑

Lembre-se que estas questões referem-se ao grau de confiança que sente face à sua capacidade atual sendo que:
1= Nada Confiante 2= Um pouco confiante 3= Confiante
4= Muito Confiante 5= Totalmente Confiante

	1	2	3	4	5
CRIATIVIDADE E INOVAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
ADAPTAÇÃO E FLEXIBILIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
APRENDIZAGEM AO LONGO DA VIDA	❑	❑	❑	❑	❑

	1	2	3	4	5
CAPACIDADE DE CONCEPTUALIZAR	❑	❑	❑	❑	❑

	1	2	3	4	5
TRABALHO EM EQUIPA	❑	❑	❑	❑	❑

	1	2	3	4	5
MOTIVAÇÃO PARA A EXCELÊNCIA	❑	❑	❑	❑	❑

	1	2	3	4	5
DIVERSIDADE / MULTICULTURALIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
ÉTICA E RESPONSABILIDADE SOCIAL	❑	❑	❑	❑	❑

	1	2	3	4	5
UTILIZAÇÃO DE NOVAS TECNOLOGIAS DA INFORMAÇÃO E DA COMUNICAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
DOMÍNIO DE LÍNGUAS ESTRANGEIRAS	❑	❑	❑	❑	❑

	1	2	3	4	5
COMPETÊNCIAS TÉCNICAS DA ÁREA ESPECÍFICA DE CONHECIMENTO	❑	❑	❑	❑	❑

COMPETÊNCIAS TRANSVERSAIS - Preparação dada pelo percurso académico

Para cada área de competências abaixo apresentada, indique a preparação dada pelo seu percurso académico nessa área de competências.
1. Muito Baixa 2. Baixa 3. Média 4. Elevada 5. Muito Elevada

Pode clicar no ícone "?" acima de cada competência para visualizar a respetiva definição.

	1	2	3	4	5
ANÁLISE E RESOLUÇÃO DE PROBLEMAS	❑	❑	❑	❑	❑

	1	2	3	4	5
TOMADA DE DECISÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
PLANEAMENTO E ORGANIZAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
GESTÃO DO TEMPO	❑	❑	❑	❑	❑

	1	2	3	4	5
ASSUNÇÃO DO RISCO	❑	❑	❑	❑	❑

	1	2	3	4	5
EXPRESSÃO ORAL	❑	❑	❑	❑	❑

	1	2	3	4	5
ESCUTA ATIVA	❑	❑	❑	❑	❑

	1	2	3	4	5
COMUNICAÇÃO ESCRITA	❑	❑	❑	❑	❑

	1	2	3	4	5
RELACIONAMENTO INTERPESSOAL E GESTÃO DE CONFLITOS	❑	❑	❑	❑	❑

	1	2	3	4	5
LIDERANÇA	❑	❑	❑	❑	❑

Lembre-se que estas questões referem-se à preparação dada pelo seu percurso académico sendo que: 1. Muito Baixa 2. Baixa 3. Média 4. Elevada 5. Muito Elevada

	1	2	3	4	5
CRIATIVIDADE E INOVAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
ADAPTAÇÃO E FLEXIBILIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
APRENDIZAGEM AO LONGO DA VIDA	❑	❑	❑	❑	❑

	1	2	3	4	5
CAPACIDADE DE CONCEPTUALIZAR	❑	❑	❑	❑	❑

	1	2	3	4	5
TRABALHO EM EQUIPA	❑	❑	❑	❑	❑

	1	2	3	4	5
MOTIVAÇÃO PARA A EXCELÊNCIA	❑	❑	❑	❑	❑

	1	2	3	4	5
DIVERSIDADE / MULTICULTURALIDADE	❑	❑	❑	❑	❑

	1	2	3	4	5
ÉTICA E RESPONSABILIDADE SOCIAL	❑	❑	❑	❑	❑

	1	2	3	4	5
UTILIZAÇÃO DE NOVAS TECNOLOGIAS DA INFORMAÇÃO E DA COMUNICAÇÃO	❑	❑	❑	❑	❑

	1	2	3	4	5
DOMÍNIO DE LÍNGUAS ESTRANGEIRAS	❑	❑	❑	❑	❑

	1	2	3	4	5
COMPETÊNCIAS TÉCNICAS DA ÁREA ESPECÍFICA DE CONHECIMENTO	❑	❑	❑	❑	❑

Género
1. Masculino

2. Feminino

Idade (Só se aceitam números inteiros).

Qual o grau académico mais elevado que concluiu?
1. Licenciatura

2. Mestrado

3. Mestrado integrado

4. Doutoramento

5. Outro. Qual?

Indique o nome do curso correspondente ao grau mais elevado que concluiu no Ensino Superior:

Caso pretenda ser convidado/a para uma sessão de apresentação dos resultados deste estudo, escreva abaixo o seu email.

Annex II - Data obtained from SPSS

Table 9: Analyses of variance of the effect of the knowledge area on the level of use of transversal skills in the professional context

Skills	Statistics			
	F	*p*	η^2	OP
Analysis and problem-solving	**3,886***	**0,021**	**0,011**	**0,702**
Decision-making	1,034	0,356	0,003	0,0231
Planning and organization	2,068	0,127	0,006	0,426
Time management	1,219	0,296	0,004	0,267
Risk-taking	2,084	0,125	0,006	0,429
Oral communication	**16,137****	**0,000**	**0,045**	**1,000**
Active listening	**17,187****	**0,000**	**0,048**	**1,000**
Written communication	**7,526****	**0,001**	**0,022**	**0,944**
Interpersonal relationships and conflict management	**8,335****	**0,000**	**0,024**	**0,963**
Leadership	1,130	0,323	0,003	0,250
Creativity and Innovation	**13,245****	**0,000**	**0,037**	**0,998**
Flexibility and Adaptation	1,113	0,329	0,003	0,246
Lifelong Learning	**5,599****	**0,004**	**0,016**	**0,858**
Ability to conceptualize	**9,169****	**0,000**	**0,026**	**0,976**
Team work	2,775	0,063	0,008	0,547
Striving for Excellence	1,056	0,348	0,003	0,235
Diversity and multiculturality	1,501	0,224	0,004	0,321
Ethics and social responsibility	**3,972***	**0,019**	**0,012**	**0,712**
Information and communication technologies	3,006*	0,050	0,009	0,583
Proficiency in foreign languages	**11,515****	**0,000**	**0,033**	**0,994**
Field-specific skills	**13,273****	**0,000**	**0,038**	**0,998**

Note: η^2 = effect size
Values in bold represent skills with statistically significance
*p <0,05 ** p< 0,01

For an easier visualization on the following tables related to the post hoc Tukey HSD tests, we opted to present only the statically significant results and to represent the different CNAEF groups as numeric variables as following:

1	Social Sciences, Commerce and Law
2	Sciences, Mathematics and Informatics
3	Engineering, Manufacturing and Construction

Table 10: Tukey post hoc test on significant parameters for differences between the different knowledge areas according to the level of use in the professional context

Dependent variable	Knowledge area (I)	Knowledge area (J)	Mean difference (I-J)	Std. Error	*p*	Confidence interval 95%	
						Lower Bound	Upper Bound
Analysis and problem-solving	1	3	-,18*	0,073	0,033	-0,36	-0,01
Oral communication	1	2	,34**	0,092	0,001	0,12	0,55
		3	,44**	0,081	0,000	0,24	0,63
Active listening	1	2	,27**	0,088	0,006	0,06	0,48
		3	,44**	0,077	0,000	0,26	0,63
Written communication	1	2	,24*	0,098	0,036	0,01	0,48
		3	,32**	0,087	0,001	0,11	0,52
Interpersonal relationships and conflict management	1	3	,34**	0,085	0,000	0,14	0,54
Creativity and Innovation	1	2	-,46**	0,102	0,000	-0,70	-0,22
		3	-,35**	0,090	0,000	-0,57	-0,14
Lifelong Learning	1	2	-,25*	0,091	0,018	-0,46	-0,03
		3	-,22*	0,080	0,015	-0,41	-0,03
Ability to conceptualize	1	2	-,34**	0,094	0,001	-0,56	-0,12
		3	-,28**	0,083	0,002	-0,48	-0,09
Ethics and social responsibility	1	3	,21*	0,089	0,047	0,00	0,42
	2	3	,27*	0,108	0,035	0,02	0,52
Proficiency in foreign languages	1	2	-,38**	0,119	0,005	-0,65	-0,10
		3	-,47**	0,105	0,000	-0,72	-0,22
Field-specific skills	1	3	-,40**	0,101	0,000	-0,64	-0,16

*p <0,05 ** p< 0,01

Table 11: Analyses of variance for the effect of the knowledge area on the level of confidence of transversal skills

Skills	Statistics			
	F	*p*	η^2	OP
Analysis and problem-solving	**3,915***	**0,020**	**0,010**	**0,706**
Decision-making	0,177	0,838	0,000	0,077
Planning and organization	**3,510***	**0,030**	**0,009**	**0,655**
Time management	0,112	0,894	0,000	0,067
Risk-taking	2,963	0,052	0,008	0,577
Oral communication	**7,578****	**0,001**	**0,019**	**0,945**
Active listening	**5,018****	**0,007**	**0,013**	**0,815**
Written communication	**6,482****	**0,002**	**0,017**	**0,906**
Interpersonal relationships and conflict management	0,540	0,583	0,001	0,140
Leadership	0,064	0,938	0,000	0,060
Creativity and Innovation	**7,461****	**0,001**	**0,019**	**0,942**
Flexibility and adaptation	1,712	0,181	0,004	0,361
Lifelong Learning	1,955	0,142	0,005	0,406
Ability to conceptualize	**4,698****	**0,009**	**0,012**	**0,788**
Teamwork	2,165	0,116	0,006	0,444
Striving for excellence	1,393	0,249	0,004	0,300
Diversity and multiculturality	2,393	0,092	0,006	0,484
Ethics and social responsibility	2,056	0,129	0,005	0,424
Information and communication technologies	**6,288****	**0,002**	**0,016**	**0,897**
Proficiency in foreign languages	**4,432***	**0,012**	**0,011**	**0,762**
Field-specific skills	**4,559***	**0,011**	**0,012**	**0,775**

Note: η^2 = effect size

Values in bold represent skills with statistically significance

*p <0,05 ** p< 0,01

Table 12: Tukey post hoc test on significant parameters for differences between the different knowledge areas according to the level of confidence in the professional context

Dependent variable	Knowledge area (I)	Knowledge area (J)	Mean difference (I-J)	Std. Error	*p*	Confidence interva 95%	
						Lower Bound	Upper Bound
Analysis and problem-solving	1	3	-,15*	0,063	0,045	-0,30	0,00
Planning and organization	1	2	,20*	0,074	0,023	0,02	0,37
Oral communication	1	2	,21*	0,080	0,026	0,02	0,40
		3	,27**	0,073	0,001	0,10	0,44
Active listening	1	3	,20**	0,063	0,006	0,05	0,34
Written communication	1	2	,21*	0,071	0,011	0,04	0,37
		3	,20**	0,065	0,006	0,05	0,35
Creativity and Innovation	1	2	-,20*	0,079	0,029	-0,39	-0,02
		3	-,26**	0,072	0,001	-0,43	-0,09
Ability to conceptualize	1	2	-,20**	0,073	0,018	-0,37	-0,03
Information and communication technologies	1	3	-,23**	0,066	0,001	-0,39	-0,08
Proficiency in foreign languages	1	3	-,25**	0,083	0,009	-0,44	-0,05
Field-specific skills	1	3	-,19*	0,069	0,018	-0,35	-0,03

*p<0,05 ** p< 0,01

Table 13: Analyses of variance on the skills level of preparation given by HEI by knowledge area

Skills	Statistics			
	F	*p*	η^2	OP
Analysis and problem-solving	**21,873****	**0,000**	**0,054**	**1,000**
Decision-making	**4,277***	**0,014**	**0,011**	**0,746**
Planning and organization	0,728	0,483	0,002	0,174
Time management	2,451	0,087	0,006	0,494
Risk-taking	2,992	0,051	0,008	0,581
Oral communication	**8,322****	**0,000**	**0,021**	**0,963**
Active listening	**7,212****	**0,001**	**0,019**	**0,934**
Written communication	**8,442****	**0,000**	**0,022**	**0,965**
Interpersonal relationships and conflict management	1,547	0,213	0,004	0,329
Leadership	1,279	0,279	0,003	0,278
Creativity and Innovation	**13,722****	**0,000**	**0,035**	**0,998**
Flexibility and Adaptation	**5,041****	**0,007**	**0,013**	**0,817**
Lifelong Learning	**13,896****	**0,000**	**0,035**	**0,998**
Ability to conceptualize	0,928	0,396	0,002	0,211
Team work	**6,991****	**0,001**	**0,018**	**0,927**
Striving for Excellence	0,525	0,592	0,001	0,137
Diversity and multiculturality	1,962	0,141	0,005	0,407
Ethics and social responsibility	**6,783****	**0,001**	**0,017**	**0,919**
Information and communication technologies	**33,114****	**0,000**	**0,080**	**1,000**
Proficiency in foreign languages	0,228	0,796	0,001	0,086
Field-specific skills	**4,362***	**0,013**	**0,011**	**0,755**

Note: η^2 = effect size

Values in bold represent skills with statistically significance

**p* <0,05 ** *p*< 0,01

Table 14: Tukey post hoc test on significant parameters for differences between the different knowledge areas according to the level of preparation given by HEI in the professional context

Dependent variable	Knowledge area (I)	Knowledge area (J)	*Mean difference (I-J)*	Std. Error	*p*	Confidence interval 95%	
						Lower Bound	Upper Bound
Analysis and problem-solving	1	2	-,44**	0,08	0,000	-0,64	-0,24
		3	-,44**	0,07	0,000	-0,62	-0,26
Decision-making	1	2	-,25*	0,09	0,017	-0,47	-0,04
Risk-taking	1	2	-,23*	0,09	0,049	-0,45	0,00
Oral communication	1	2	,27*	0,09	0,012	0,05	0,49
		3	,32**	0,08	0,001	0,12	0,53
Active listening	1	3	,32**	0,08	0,000	0,12	0,52
Written communication	1	2	,29**	0,08	0,004	0,08	0,49
		3	,29**	0,08	0,001	0,10	0,48
Creativity and Innovation	1	2	-,32**	0,09	0,002	-0,53	-0,10
		3	-,41**	0,08	0,000	-0,61	-0,22
Flexibility and Adaptation	1	3	-,24**	0,08	0,007	-0,43	-0,05
Lifelong Learning	1	2	-,43**	0,09	0,000	-0,64	-0,22
Teamwork	1	3	-,27**	0,07	0,001	0,10	0,45
Ethics and social responsibility	1	2	,29**	0,09	0,008	0,06	0,51
		3	,27**	0,08	0,005	0,07	0,48
Information and communication technologies	1	2	-,60**	0,09	0,000	-0,82	-0,38
		3	-,58**	0,08	0,000	-0,78	-0,38
Field-specific skills	1	2	-,21*	0,08	0,043	-0,41	0,00
		3	-,19*	0,07	0,035	-0,38	-0,01

* $p < 0,05$ ** $p < 0,01$